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COMPARATIVE TOXICITY OF THE VAPORS OF SEVERAL CHLORINATED METHANE AND ETHANE DERIVATIVES TO THE RICE WEEVIL [1]

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Received July 23, 1951

The investigation reported here was concerned with the comparative toxicity to the adult rice weevil, *Sitophilus oryza* (L.), of the vapors of several chlorinated hydrocarbon compounds. Concentration and exposure time were varied widely to discover, if possible, any relationship which might appear under these conditions between the chemical structure or known chemical reactivity and toxicity of the compounds.

Three methane and four ethane derivatives were chosen for this purpose. The methane derivatives were methylene chloride, chloroform, and carbon tetrachloride which form a series of compounds differing from one another, in the order named, by a single chlorine atom. In structure, they are the simplest of the chlorinated hydrocarbons. The ethane derivatives were the two dichloro- and the two trichloroethanes, consisting respectively of the asymmetrical 1,1-dichloroethane and the symmetrical 1,2-dichloroethane (ethylene dichloride), and the asymmetrical 1,1,1-trichloroethane and 1,1,2-trichloroethane. These ethane derivatives provided an opportunity to test compounds in which two or three chlorine atoms are attached to a single carbon atom and to both carbon atoms of the ethane chain.

Although these compounds have been tested previously on various species of insects (the literature has been covered exhaustively by Sun [10], Ferguson and co-workers [5, 6]), little information has been reported on their toxic activities at exposures of less than 20 minutes to 24 hours or longer, a subject of principal concern in this study.

Busvine (1) has emphasized the desirability of determining the toxicity of insecticides on more than one test insect. Practical considerations forced the writer to restrict the investigation to a single species; and although this species is a member of a dominant family of insects, no assurance can be given that the results would lend themselves to unrestricted generalization.

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[1] Journal Paper No. J-1978 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project 1095.

[2] The writer is indebted to John K. Reed, David A. Carlson, and H. Ross Watson for assistance with this project.

MATERIALS AND METHODS

The adult rice weevils were reared in corn (maize) at 20° to 30°C. and relative air humidity of 70 to 80 per cent. The compounds used were of C.P. or U.S.P. grade or of the best commercial grade obtainable.

All tests were made in the laboratory and were of two kinds: in air saturated with the test compound at 30°C. and in air at various concentrations less than saturation also at 30°C. Each compound was tested either at a fixed concentration and a number of exposure times to furnish time-mortality curves or at a series of fixed exposure times and variable concentrations to furnish concentration-mortality curves; from these curves the LD_{50} value for each exposure time was calculated.

The apparatus for testing toxicity of the methane derivatives at saturation in air consisted of three gas washing bottles containing the test liquid compound connected with a 3.8 liter bottle which held enough glass wool to cover the bottom and to which was added a small volume of the test compound. The tube from the chain of gas washing bottles dipped into the liquid beneath the glass wool, giving, in effect, a system of four saturators. Before each test, air was passed through the system by suction till no change occurred in the level of the liquid in the gas washing bottle next to the large bottle, and till ample time had elapsed to fill the bottle with saturated air (approximately eight times the volume of air in the large bottle). Then the air flow was stopped and the system was brought to the prevailing barometric pressure by slow inflow of air through the absorption chain. The stopper in the large bottle was removed, a cage of insects was quickly suspended in the bottle, and the stopper was replaced. The operation required only a few seconds. After the desired time had elapsed, the cage was removed, and the insects were treated as indicated below.

Saturated concentrations of the ethane derivatives were obtained by placing an excess of the liquid compounds in small-necked bottles of 11.68 liters capacity, and allowing the bottles to stand for some time at 30°C. with occasional shaking. The time to reach saturation was predetermined roughly by observing the time for complete evaporation of a graded series of doses in dry bottles. The cages of insects were introduced quickly into the bottles containing the saturated concentrations as described below for the tests with concentrations less than saturation.

The vapor concentration at saturation was calculated from the usual gas-law formula, $g = p\ PvM/760\ RT$, modified by taking $V = v^1 \dfrac{P}{P-p}$, in which v^1 is the volume of air before saturation, P is the barometric pressure, and p is the vapor pressure of the liquid. The modification gives effect to the increase in volume brought about by introduction of

the vapor (3, p. 173). The other symbols have their usual meanings. The calculations gave the following vapor concentrations in air at saturation (atmospheric moisture was disregarded) for 30°C. and 760 mm. Hg: methylene chloride 1.34 gram per liter; chloroform 1.17 gram; carbon tetrachloride 0.98 gram; 1,1-dichloroethane 1.07 gram; 1,2-dichloroethane 0.46 gram; 1,1,1-trichloroethane 0.80 gram; 1,1,2-trichloroethane 0.23 gram.

Concentrations less than saturation were tested in glass bottles of 11.68 or 19.38 liters capacity. The dose of test compound was delivered from a burette graduated in 0.01 ml. units into a bottle that had previously been brought to a temperature of 30°C. As soon as the charge was introduced, a cage of insects was suspended in the bottle, a cork stopper was fitted, and the bottle was twirled so that the liquid compound would spread over a large area of the wall surface and evaporate rapidly. The cage was whirled within the bottle for a few seconds to hasten diffusion of the vapor. The entire operation required less than a minute. The stopper was then sealed with a hot beeswax-paraffin mixture, and the bottle was held at 30°C. for the required exposure. After that time had elapsed, the insects were removed, provided with several half kernels of water-soaked corn, and held at room temperature and 70 to 80 per cent relative humidity for the determinaton of percentage of mortality. This reading was taken five days after the beginning of the test. Insects which could not then walk on a flat surface were considered dead.

The samples of about fifty insects were drawn at random from large pooled lots of individuals. Data from samples exposed to the vapors were not used if the accompanying control samples showed more than 2 per cent mortality.

Regression lines were fitted to logarithms of the exposure times (in minutes) and to logarithms of the concentrations (in grams per liter) for 50 per cent mortality (LD_{50}).

RESULTS

The results of the time-mortality studies are shown in Figures 1, 2, 3, and 4. Figures 1 and 2 relate the median lethal concentrations (LD_{50}) of the ethanes and methanes respectively with exposure time; Figure 3 compares a set of time-mortality data with a set of concentration-mortality data from tests with carbon tetrachloride, each set being derived from independent observations; and Figure 4 compares 1,2-dichloroethane (ethylene dichloride) with carbon tetrachloride on the basis of LD_{50} and exposure time.

DISCUSSION

At saturation, the ethane derivatives (Fig. 1) show various concentrations and median exposure times (LT_{50}), no one of which is common to all the compounds; but if toxicity is expressed as the products of the concentration and LT_{50} (minutes), the following decreasing order of

toxicity is obtained (products in parentheses): 1,1,2-trichloroethane (5.2); 1,2-dichloroethane (8.0); 1,1-dichloroethane (12.2); 1,1,1-trichloroethane (18.0). The first two compounds maintain the same order of toxicity at all other exposure times tested up to 1,440 minutes; the remaining two compounds reverse their positions after 180 minutes, 1,1,1-trichloroethane becoming more toxic at the longer exposure times. Three of the compounds exhibit two curves, one of relatively flat slope extending from LT_{50} at saturation to about 100 minutes, the other of much steeper

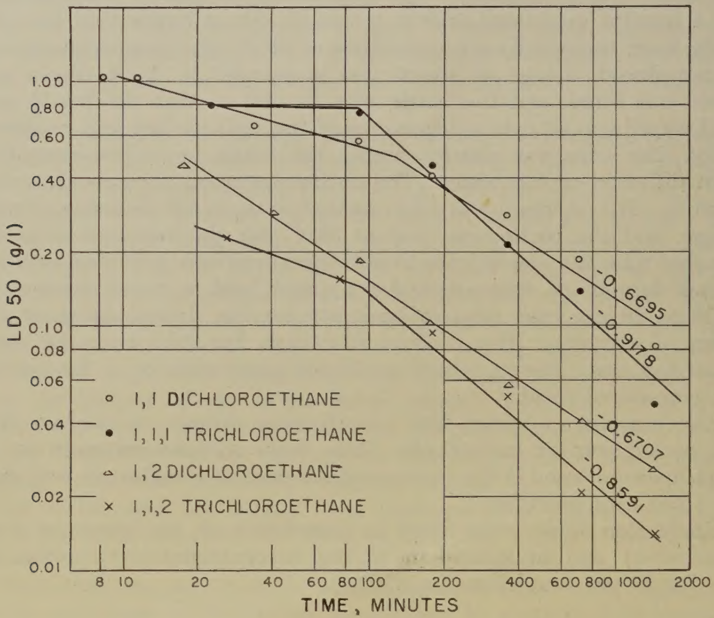

FIG. 1.—Comparison of four chloroethane compounds.

slope extending from about 100 to 1,440 minutes. However, the data for 1,2-dichloroethane approximate a straight-line trend over the entire period of exposures.

The ethane derivatives fall into two distinct groups with respect to toxicity to *S. oryza*. In the more toxic group, chlorine atoms are attached to both carbon atoms, while in the less toxic group all the chlorine atoms are attached to a single carbon atom of the ethane chain. Thus toxicity is strongly correlated with place isomerism involving the distribution of the chlorine atoms in the ethane molecule.

Another striking feature of these data (Fig. 1) is the similarity in the slopes of the steeper regression lines of the two dichloroethanes and the two trichloroethanes respectively. The slopes for the dichloroethanes are identical, and those for the trichloroethanes are essentially parallel.

Evidently, slope, which represents here the rate of decrease in LD_{50}, is correlated in these compounds with the total number of chlorine atoms in the ethane molecule rather than with their distribution.

Discussion of the toxic action of the chloroethane compounds may well begin with a consideration of their solvent powers. Differences in solvent power may influence the rates of penetration of the vapors into exterior body surfaces and diffusion of the absorbed compounds within the body of the insect. Rapidly penetrating and diffusing compounds might arrive at vital centers and initiate toxic activity before more slowly penetrating compounds could reach them. Differences in solvent power may be concerned also in the degree of selective dislocation and redistribution of vital substances in tissues, and perhaps, in their wider translocation within the organism. Studies by Van Braam Houckgeest (12, 13, 14) on the solvent and dissociating powers of several chloroethane compounds for certain alkylammonium halides bear interestingly on these questions. It was found that the solubilities and degrees of dissociation of these halides in 1,2-dichloroethane and 1,1,2-trichloroethane were among the highest observed in the solvents examined, and they were among the lowest in 1,1-dichloroethane and 1,1,1-trichloroethane. The two chloroethanes with high solvent and dissociating power are the ones that proved most toxic to *S. oryza*, whereas the two compounds with low solvent and dissociating powers were definitely lower in toxicity to this insect. There seems to be little doubt that solvent power and perhaps dissociating power also are important factors in determining the toxicity of these compounds to *S. oryza*; nevertheless, differences in chemical reactivity cannot be excluded though they appear at this time less important in these relatively stable compounds.

The regression lines for the chloromethane derivatives are shown in Figure 2. At saturation, the products of concentration and LT_{50} place these compounds in the following order of toxicity: chloroform (7.6); carbon tetrachloride (11.2); methylene chloride (18.2). The data for both methylene chloride and chloroform follow a straight-line trend over the entire exposure period, and the close approach of the two lines to parallelism indicates a similar rate of decrease of LD_{50} with increasing time. On the other hand, the data for carbon tetrachloride like those for 1,1-dichloroethane and for the two trichloroethane compounds establish two lines of different slope; the upper line of moderate slope extends from LT_{50} at saturation to about 80 minutes, the lower line of much steeper slope from 80 minutes to the end of the exposure period.

Chloroform is clearly more toxic than methylene chloride at all exposure times; carbon tetrachloride starts from an intermediate position, becomes approximately equal in toxicity to methylene chloride at 80 minutes; after 100 minutes it becomes increasingly more toxic than methylene chloride, and after 500 minutes it exceeds chloroform in toxicity; finally at 1,440 minutes it approaches 1,2-dichloroethane in

toxicity (see Fig. 4). The validity of the position and slope of the lower line for carbon tetrachloride is supported by a second regression line calculated from independent data (Fig. 3). The rate of decrease of LD_{50} with increasing time after 100 minutes is greater for carbon tetrachloride than for the other compounds used in this investigation; only the rates for the trichloroethanes approach it at all closely.

Differences in solvent power are probably concerned also in the relative toxic effectiveness of the chloromethane derivatives on *S. oryza.*

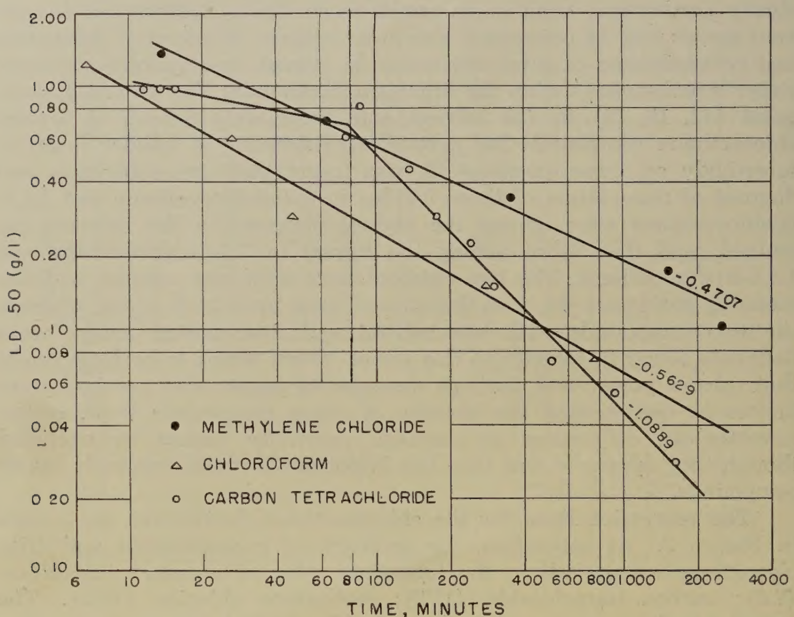

Fig. 2.—Comparison of three chloromethane compounds.

Van Braam Houckgeest (13) found that chloroform had even greater solvent power than the chloroethane derivatives for most of the alkylammonium halides tested. He did not study methylene chloride or carbon tetrachloride but they are known to be excellent solvents for many substances. However, differences in chemical reactivity are probably of greater significance for toxicity in the chloromethane derivatives than in the relatively stable chloroethane derivatives tested in this investigation.

Chemically, methylene chloride is the most stable of these chloromethanes. It resists decomposition by atmospheric oxygen, by water, and by most metals at temperatures well beyond those tolerated by living organisms (2). If it is decomposed at all by the insect, decomposi-

tion is probably only partial and most likely the products are of simple structure and less toxic than methylene chloride itself. Low relative solvent power probably determines the relatively low toxicity of methylene chloride to *S. oryza.*

Chloroform, on the other hand, is much more reactive chemically than methylene chloride. It is easily decomposed by atmospheric oxygen

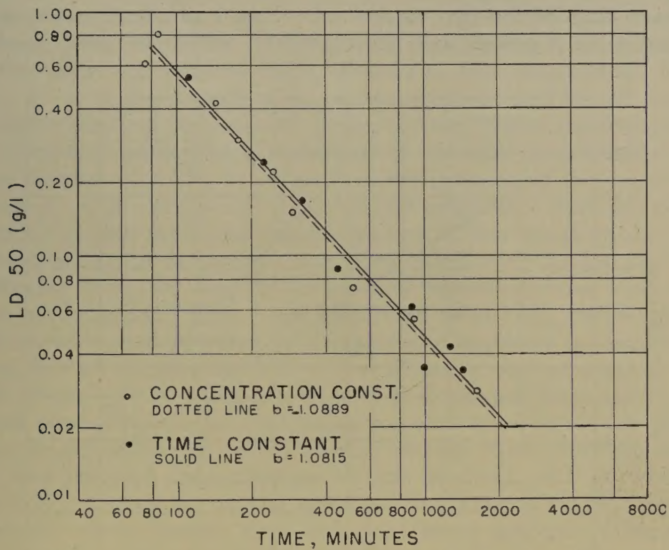

FIG. 3.—CCl_4.

(*loc. cit.*) and is dehalogenated rapidly in the cold in an alkaline alcoholic-acetone solution (8). Urbaine (11) has proposed a molecular

structure for chloroform, $Cl_2{>}C - Cl.H$, in place of the classical form,

$Cl - C(Cl)(Cl) - H$; such a compound could react as though it were a hydrochloride of carbon dichloride (CCl_2). Conceivably, the $Cl_2{>}C - Cl -$ group or the $Cl_2{>}C -$ group could become attached to some vital com-

plex in the insect and give rise to toxic manifestations. Kolthoff *et al.* (7) find that chloroform is reduced at the dropping mercury electrode at 25°C.; they suggest the following over-all reaction for this reduction: $CHCl_3 + H^+ + 2e \rightarrow CH_2Cl_2 + Cl^-$ *or* ($CHCl_3 + H_2O + 2e \rightarrow CH_2Cl_2 + Cl^- + OH^-$). In either case, methylene chloride is the only toxic product formed. That methylene chloride is also the end product of chloroform decomposition in *S. oryza* is suggested by the similarity in slope of the regression lines of the two compounds. Rapid penetration owing to its excellent solvent power, and decomposition within the body leading to

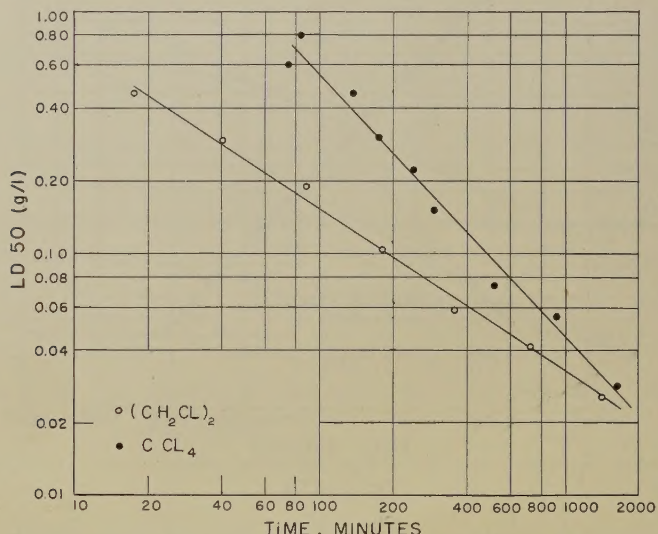

FIG. 4.—Comparison of 1,2-dichloroethane and carbon tetrachloride.

the formation of toxic compounds and with the still toxic methylene chloride as the end product, are suggested to account for the relative toxic superiority of chloroform over methylene chloride.

Carbon tetrachloride is intermediate in chemical stability between methylene chloride and chloroform. It is fairly stable to heat but unlike chloroform it is not reduced by Fehling's solution (9). However, it is reduced more readily than chloroform at the dropping mercury electrode (7), with chloroform and either chloride ions or both chloride and hydroxyl ions as reduction products. The rapid downtrend of the regression line for carbon tetrachloride which reaches and extends below that for chloroform points strongly to the formation of chloroform (or of some compound closely related to it) in carbon tetrachloride-poisoned *S. oryza*. The good solvent power of carbon tetrachloride is probably an additional determinative factor in its toxicity.

CHEMICAL POTENTIALS AND EXPOSURE TIME

In several articles, Ferguson and co-workers (4, 5, 6) contend that valid conclusions regarding the toxicity of a substance can be reached only if account is taken of its phase distribution within the organism; that the external concentration may, in fact, be quite different from the concentration in some biophase — for example, in the hemolymph of an insect; and if valid conclusions concerning the effect of chemical structure, etc. on toxicity are to be inferred from external concentration alone, then the effect of phase distribution must be eliminated. With the latter purpose in mind, Ferguson (4) proposed to express toxicity by an index based on the thermodynamic activity of the toxicant rather than on its external concentration. For a toxic vapor, the thermodynamic activity was considered to be equal numerically to the relative saturation, P_t/P_s, in which P_t is the pressure of the vapor which produces a certain mortality (here 50 per cent) at a certain temperature, and P_s is the saturated vapor pressure at that temperature.

Thermodynamic activity indices were calculated (5) for the vapors of a diverse group of organic compounds including those used in the present investigation. They were calculated from LD_{50} values obtained from tests with granary weevils [*Sitophilus* (*Calandra*) *granarius* (L.)] exposed for 300 minutes at 25°C. to the vapors of the compounds. Compounds whose vapors furnished indices that ranged from about 0.1 to 1.0 were considered to be representative of a class in which physical toxicity predominates, in which an equilibrium exists between the external and internal concentrations of the toxicant, and in which the toxicant is not used up by the organism but acts as entire molecules. Compounds whose vapors gave definitely lower indices, ranging from about 0.08 to 0.0004, were said to exhibit predominantly chemical toxicity. For these compounds equilibrium conditions are not considered important in determining the value of the external concentrations. Indices intermediate between those representative of chemical toxicity were reported for some compounds.

These authors placed all the chloromethane and chloroethane compounds under discussion in the single category which manifests physical toxicity with indices ranging from 0.19 to 0.32. Since our study revealed some rather marked differences in toxicity among these compounds, it seemed desirable to calculate indices from our data for 300 minutes, and for a shorter and a longer exposure period. Periods of 100 and 1,000 minutes were chosen for this purpose. Indices were also calculated from data by Sun (10) taken from experiments with carbon disulfide vapor applied for several exposure periods to both *S. granarius* and *S. oryza*. Carbon disulfide is of special interest here as representative of a compound which, according to Ferguson and Pirie, manifests primarily chemical activity. The data are brought together in Table 1.

Several points are emphasized by the information presented in this table: (1) The indices always decrease with increase in length of the exposure time; (2) the magnitude of the decrease for the chloro-

TABLE 1

CHEMICAL POTENTIALS AS INDICES OF TOXICITY AT SEVERAL EXPOSURE TIMES

Compound	Insect	Exposure (Minutes)	Temp. °C.	LD_{50} g/liter	P_t/P_s	Type of Toxicity	Source of Data
Methylene chloride....	*Sitophilus oryza*	100	30	0.561	0.244	Physical	C. H. Richardson
" "	" "	300	30	0.337	0.147	"	" " "
" "	" "	1,000	30	0.193	0.084	Chemical?	" " "
Chloroform..........	" "	100	30	0.245	0.157	Physical	" " "
"	" "	300	30	0.132	0.085	Chemical?	" " "
"	" "	1,000	30	0.067	0.043	Chemical	" " "
Carbon tetrachloride..	" "	100	30	0.548	0.470	Physical	" " "
" " ..	" "	300	30	0.168	0.144	"	" " "
" " ..	" "	1,000	30	0.046	0.039	Chemical	" " "
Methylene chloride....	*S. granarius*	300	25	0.380	0.19	Physical	Ferguson and Pirie (1948)
Chloroform..........	" "	300	25	0.250	0.20	"	" " " "
Carbon tetrachloride..	" "	300	25	0.275	0.29	"	" " " "
Carbon disulfide......	" "	90	25	0.093	0.064	Chemical	Sun (1947)
" "	" "	150	25	0.054	0.037	"	" "
" "	" "	300	25	0.033	0.023	"	" "
" "	" "	300	25	0.03	0.02	"	Ferguson and Pirie (1948)
" "	" "	600	25	0.022	0.015	"	Sun (1947)
" "	*S. oryza*	90	25	0.057	0.039	"	" "
" "	" "	150	25	0.037	0.026	"	" "
" "	" "	300	25	0.022	0.015	"	" "
" "	" "	600	25	0.013	0.009	"	" "

TABLE 1—(*continued*)

CHEMICAL POTENTIALS AS INDICES OF TOXICITY AT SEVERAL EXPOSURE TIMES

Compound	Insect	Exposure (Minutes)	Temp. °C.	LD_{50} g/liter	P_t/P_s	Type of Toxicity	Source of Data
1,1-Dichloroethane....	*S. oryza*	100	30	0.598	0.409	Physical	C. H. Richardson
" "	" "	300	30	0.286	0.196	"	" " "
" "	" "	1,000	30	0.128	0.088	Chemical	" " "
1,2-Dichloroethane....	" "	100	30	0.157	0.300	Physical	" " "
" "	" "	300	30	0.075	0.144	"	" " "
" "	" "	1,000	30	0.033	0.063	Chemical	" " "
1,1,1-Trichloroethane..	" "	100	30	0.705	0.755	Physical	" " "
" " ..	" "	300	30	0.257	0.275	"	" " "
" " ..	" "	1,000	30	0.085	0.091	Chemical?	" " "
1,1,2-Trichloroethane..	" "	100	30	0.136	0.568	Physical	" " "
" " ..	" "	300	30	0.053	0.221	"	" " "
" " ..	" "	1,000	30	0.019	0.079	Chemical	" " "
1,1-Dichloroethane....	*S. granarius*	300	25	0.380	0.32	Physical	Ferguson and Pirie (1948)
1,2-Dichloroethane....	" "	300	25	0.099	0.24	"	" " "
1,1,1-Trichloroethane..	" "	300	25	0.290	0.31	"	" " "
1,1,2-Trichloroethane..	" "	300	25	0.053	0.30	"	" " "

methane and chloroethane compounds is such that the indices approach or fall well within the limits indicated for chemical toxicity; (3) the indices for carbon disulfide likewise decrease with increase of exposure time although they always remain within the limits fixed for chemical toxicity; (4) the indices reveal differences associated with the species of test insect.

Discussion at length of the value of the thermodynamic activity concept in the interpretation of relationships between the chemical structure and toxicity of insecticides is beyond the scope of this investigation. It seems desirable to point out, however, that the indices based on this concept for the chloromethane and chloroethane compounds considered here have failed to express toxicity accurately when toxicity has been determined at several widely spaced exposure times. Under these conditions, apparently, the same compound may exhibit "physical toxicity" at one exposure time and "chemical toxicity" at another.

The possibility that the toxic action of these compounds at high gas concentration (and consequently at relatively short exposure time) is largely a physical process and that the inrush of concentrated vapor is sufficient to overwhelm lethal chemical processes which may function during the longer exposure to lower gas concentration must be admitted; but the validity of such an explanation must rest on future investigation.

SUMMARY

Adult rice weevils [*Sitophilus oryza* (L.)] were exposed to the vapors of several chloromethane and chloroethane compounds over the range from short intervals (less than 20 minutes) in air saturated with the compounds to long intervals (24 hours or more) at lower vapor concentrations. Methods of rearing and sampling the insects and of making the toxicity tests are described.

The more toxic chloroethane derivatives, 1,2-dichloroethane and 1,1,2-trichloroethane, have chlorine atoms attached to both carbons of the ethane chain; the less toxic derivatives, 1,1-dichloroethane and 1,1,1-trichloroethane, have all the chlorine atoms attached to a single carbon atom. However, the slopes of the lines from the regression of the logarithms of LD_{50} on time (minutes) for the two chloromethane and the two chloroethane compounds respectively are similar. Thus toxicity in the ethane compounds is strongly correlated with the distribution (place isomerism) of the chlorine atoms, whereas the slope representing the rate of decrease of LD_{50} is correlated with the number of chlorine atoms per molecule.

Solvent power (and possibly also the degree of dissociation for vital dissolved compounds) is probably more important than chemical reactivity in determining the toxicity of these relatively stable chloroethane derivatives, but the possibility that chemical reactivity may be important cannot be overlooked.

Among the chloromethane compounds, chloroform was more toxic than methylene chloride at all exposure times. Carbon tetrachloride

was less toxic than chloroform at exposure times less than 500 minutes but thereafter became increasingly more toxic till at 1,440 minutes it approached 1,2-dichloroethane in toxicity.

Solvent power is probably concerned also in the relative toxic effectiveness of the chloromethane compounds, methylene chloride, chloroform, and carbon tetrachloride; however, chemical reactivity is thought to be more important in determining toxicity, particularly in chloroform and in carbon tetrachloride, than in the chloroethane compounds studied.

Indices of toxicity based on the thermodynamic activity concept are not stable but tend to assume lower values with increase in exposure time.

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EFFECTS OF HEMORRHAGE, CAUTERIZATION, LIGATION, DESICCATION, AND STARVATION ON HEMOCYTES OF MEALWORM LARVAE (*TENEBRIO MOLITOR* L.)[1]

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Received August 9, 1951

While hemocyte classifications (28, 38) and total hemocyte counts (33, 34) have been presented for many insects, only incidental observations have been made on both total and differential hemocyte counts from a few insects under various physiological conditions.

For the present paper, total and differential hemocyte counts have been made on 421 mealworm larvae (*Tenebrio molitor*) subjected either to hemorrhage, severe cautery, ligation, desiccation, or starvation. Counts showing the effects of various insecticides on the hemocyte picture of *T. molitor* will be presented in another paper. It is hoped that shifts in the hemocyte populations, either total or differential, or both, may lead to the formulation of suggestive criteria which will reflect physiological changes taking place in an insect under various physical and biochemical stresses.

MATERIALS AND METHODS

Mealworm larvae weighed approximately 95 to 175 mg., measured from 25 to 30 mm., had not recently molted, and were not about to molt or pupate. However, neither exact chronological age, instar, nor sex was determined.

Total hemocyte counts were made by diluting heat-fixed hemolymph in a Thoma white cell pipette and counting the cells in a Neubauer double-line hemocytometer, as previously described (19). Hemocyte classes were identified, by a modification of Yeager's (38) classification of *Prodenia* hemocytes, from heat-fixed, Wright stained hemolymph smears (18).

To explore and expand the possibility of identifying internal physiological changes by alterations in the hemocyte picture, some additional special counts were made. These included: (1) mitotic figures (M), 1,000 cells counted; (2) fusiform (passive) cells (F), 100 cells counted; (3) pathological cells (PC), 100 to 1,000 cells counted; and (4) cells

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with small nuclei (CSN), arbitrary limits chosen as 3.5 micra, 100 to 1,000 cells counted.

Hemorrhages were induced by amputating the anterior pair of larval legs, or by sterile needle insertion into the hemocoele. The amount of hemolymph lost was not measured.

Larvae were cauterized by a one second application of a red hot needle tip to the dorsal surface of the abdomen, laterad of the heart.

Ligatures were placed about the abdomen between various segments, as tabulated in results under "Ligature site." Ligation times varied from 24 hours to as long as 35 days. Most larvae did not survive prolonged ligaturing. To rule out the possibility of bacterial infections incident to ligaturing, hemolymph inoculations on nutrient agar plates and enriched beef infusion broth were kept at 27°C. for one week. Cultures were not made for all ligatured larvae; however, enough were made to establish that in most cases where bacteria were not visible in stained hemolymph smears the larvae were not suffering from the complication of bacteremia. The hemolymph of 90 per cent of the ligatured larvae examined was sterile. Bacteria were not identified in those cases where infection was noted.

Larvae were desiccated over calcium chloride and fed on a thoroughly dried diet of bran and dog food for 7, 14, or 30 day periods. Completely starved larvae were kept in clean petri dishes for 7, 14, 30, 55, or 60 days. One series was starved for 4 months.

All experiments were conducted at 25° to 30°C. The humidity was not controlled except in the desiccation studies.

RESULTS

Hemorrhage. Even though subjecting a larva to a single hemorrhage may, as shown by Table 1, have little effect on the differential or total hemocyte count (THC), there is a transient increase, up to an average of 0.7 per cent, in some cases, in mitotic figures (M). Mitotic counts from normal larvae rarely exceed 0.2 per cent. The increase in the prohemocytoids [3] (I) and the smooth-contour chromophilic cells (II) following sterile needle insertion, to induce hemolymph loss, is probably explained by stimulation from some inadvertent trauma. Repeated hemorrhages from the same larva are generally followed by overwhelming septicemias (mixed infections) after the second or third hemorrhage.

Cautery. Severely cauterized mealworm larvae were comatose. The burned area was melanotic, often filled with an exudate; later viscera would sometimes protrude through the site of injury if the body wall became perforated.

Hematological data for cauterized larvae are also shown in Table 1. There is a highly significant increase in the smooth contour chromophilic cells (II), in spheroidocytes (VII), and in degenerating cells (VIII);

[3] The term *prohemocytoid* was suggested by Yeager (38) as preferable to the older term *proleucocyte*. The significance of the Roman numerals, inserted in parentheses after the name of the particular hemocyte, is explained in a footnote, Table 1.

TABLE 1

MEAN DIFFERENTIAL HEMOCYTE COUNTS TOGETHER WITH SOME TOTAL HEMOCYTE COUNTS (THC) AFTER HEMORRHAGE AND AFTER CAUTERY

Time After Hemorrhage (Hours)	No. Insects Used	Hemocyte Classes (Per Cent) I	II	III	IV	VI	VII	VIII*	M†	F‡	Mean THC (Cells/mm³)
		Hemorrhage by Amputation									
24......	9	0.0	0.4	1.3	42.0	56.3	0.0	0.0	0.7	19.6	48,600
controls..	9	0.5	0.0	0.5	40.0	59.0	0.0	0.0	0.2	20.0	49,500
96......	4	0.2	0.2	1.5	38.8	58.8	0.5	0.0	0.0	9.2	46,900
controls..	4	0.1	0.1	0.3	42.5	57.0	0.0	0.0	0.0	18.0	54,000
		Hemorrhage by Needle Insertion									
24......	3	3.6	3.0	1.4	38.0	53.6	0.0	0.4	0.5	10.6	......‖
48......	5	3.4	2.0	0.2	47.2	47.2	0.0	0.0	0.2	16.6	....
		Cautery									
Time After Cautery (Hours)										PC§ *Percentage*	
1.......	2	0.0	1.5	0.5	32.0	62.5	0.0	3.5	0.2	......	.......‖
controls..	2	1.0	0.0	1.0	48.0	50.0	0.0	0.0	0.0	......	20,000
24......	3	5.5	10.5	0.5	66.0	9.0	5.0	3.5	0.2	57.0	33,500
controls..	3	1.6	0.4	0.5	48.0	49.5	0.0	0.0	0.1	......	70,000

* Symbols I through VIII refer to the following hemocyte classes: (I) prohemocytoids; (II) smooth contour chromophilic cells; (III) oenocyte-like cells; (IV) plasmatocytes; (V) vermiform cells—not included in table since they appear only in pupal hemolymph; (VI) cystocytes; (VII) spheroidocytes; and (VIII) degenerating cells.

† Mitotic index.

‡ Fusiform cells (passive forms).

§ Fusiform cells [passive forms (F)] were not counted; instead, here are figures for grossly pathological cells (PC).

‖ Hemolymph insufficient for THC.

but there is a marked reduction in the cystocytes (VI). Total hemocyte counts varied from 15,500 cells per cubic millimeter (a hemocytopenia) to 57,000 cells per cubic millimeter (an apparently normal count).

Vacuolated plasmatocytes (IV) are numerous and many of the hemocytes (20 to 95 per cent) tend to show nuclear condensation changes, especially in larvae 24 hours after cautery. Some of the hemocytes showed nuclear swelling with a tendency toward fragmentation.

Ligaturing. Hematological changes following abdominal ligation were generally evident within 19 hours, marked by an increase in plasmatocytes (IV) and spheroidocytes (VII). Ligation sites tend to become locally necrotic.

Cytological changes in the hemocyte picture after ligation were exceedingly variable. Changes noted included: (1) cytoplasmic reticu-

lation in plasmatocytes; (2) surface irregularities (development of abnormal cytoplasmic extensions referred to as "rami"); (3) abnormally shaped hemocytes (poikilohemocytes); (4) plastid formation (cytoplasmic fragments from hemocytes); (5) cytoplasmic fatty degeneration (Sudan black B method); (6) nuclear and cytoplasmic swelling; (7) occasional, sometimes numerous, giant cells (not multinucleate); (8) abnormal vacuoles in cytoplasm; (9) abnormal granule formation (enlarged basophilic or eosinophilic inclusions); (10) achromatic hemo-

TABLE 2
DIFFERENTIAL HEMOCYTE CLASS COUNTS FROM MEALWORM LARVAE, LIGATED AT VARIOUS INTERSEGMENTAL AREAS

Ligation Time	Ligature Site (Between Segments)	Hemocyte Classes (Per Cent)						
		I	II	III	IV	VI	VII	VIII
30 min.......	1 and 2	0.0	0.0	2.0	30.0	68.0	0.0	0.0
	3 and 4	0.0	0.0	2.0	34.0	64.0	0.0	0.0
	3 and 4	2.0	0.0	1.0	26.0	64.0	0.0	7.0
	5 and 6	0.0	0.0	0.0	56.0	43.0	0.0	1.0
	5 and 6	0.0	0.0	1.0	45.0	54.0	0.0	0.0
Mean.....		0.4	0.0	1.2	38.2	58.6	0.0	1.6
1.5 hr........	3 and 4	0.0	0.0	3.0	37.0	43.0	14.0	3.0
	5 and 6	3.0	0.0	1.0	25.0	71.0	0.0	0.0
	5 and 6	0.0	0.0	0.0	48.0	52.0	0.0	0.0
	5 and 6	0.0	0.0	2.0	31.0	67.0	0.0	0.0
	6 and 7	0.0	0.0	3.0	37.0	60.0	0.0	0.0
	6 and 7	0.0	0.0	1.0	36.0	63.0	0.0	0.0
Mean......		0.5	0.0	1.6	35.8	59.3	2.3	0.5
3 hr.........	3 and 4	0.0	0.0	0.0	34.0	66.0	0.0	0.0
4 hr.........	2 and 3	0.0	0.0	0.0	41.0	59.0	0.0	0.0
19 hr........	2 and 3	0.0	0.0	4.0	62.0	32.0	1.0	1.0
	2 and 3	0.0	0.0	1.0	45.0	42.0	12.0	0.0
	5 and 6	0.0	0.0	1.0	44.0	50.0	5.0	0.0
	5 and 6	0.0	0.0	0.0	35.0	62.0	1.0	2.0
	6 and 7	0.0	0.0	1.0	58.0	34.0	5.0	2.0
Mean.....		0.0	0.0	1.4	49.2	44.0	4.8	1.0
21 hr........	2 and 3	1.0	0.0	1.0	45.0	48.0	3.0	2.0
	3 and 4	0.0	0.0	3.0	42.0	48.0	0.0	7.0
	7 and 8	0.0	0.0	0.0	48.0	48.0	2.0	2.0
Mean.....		0.3	0.0	1.3	45.0	48.0	1.6	3.6
27 hr........	3 and 4	0.0	0.0	0.0	33.0	20.0	21.0	26.0
	5 and 6	0.0	0.0	0.0	62.0	30.0	8.0	0.0
	6 and 7	0.0	0.0	0.0	47.0	39.0	1.0	13.0
Mean.....		0.0	0.0	0.0	47.3	29.6	10.0	13.0

cytes; and (11) agglutination of hemocytes of all categories, but especially of plasmatocytes and prohemocytoids.

Table 2 shows that, for the most part, the blood picture of the mealworm is not materially altered in the first four hours after ligaturing, but that by 19 hours there is a notable increase in oenocyte-like cells (III), spheroidocytes (VII), and degenerating cells (VIII). The spheroidocytes and degenerating cells show a tendency to increase progressively so that by 27 hours there is a marked degenerative shift to the right, due primarily to degenerating plasmatocytes (IV). By 48 hours, however, as shown by Table 3, the blood picture is complicated by an

TABLE 3

Mean Differential Hemocyte Counts From Anterior End of Larvae Ligated at the Same Abdominal Site (Between Segments 3 and 4) for Variable Times

Ligation Time (Hours)	No. Larvae Used	I	II	III	IV	VI	VII	VIII	M	Mean THC (Cells/mm³)
									Percentage	
24	8	0.0	0.0	0.5	31.4	65.2	2.2	0.6	....	....
48	14	1.1	0.6	0.1	47.8	43.5	3.6	3.6	....	....
55	21	1.4	0.8	0.4	44.2	49.5	2.5	1.1	....	....
72	11	0.0	0.6	0.0	46.0	52.1	0.7	0.3	....	....
96	7	0.3	0.0	0.3	51.0	43.1	3.3	2.0	....	....
120	19	0.3	0.1	0.9	44.3	52.1	2.0	0.1	....	....
144	3	3.6	0.0	0.6	46.0	47.3	1.6	0.6	....	....
268	2	6.0	0.5	0.5	45.5	47.5	0.0	0.0	0.2	53,800

apparently compensatory regenerative shift, which subsequently becomes predominant in larvae surviving as much as 120 to 268 hours of ligaturing.

Individual data from six larvae ligatured between the third and fourth abdominal segments for 120 hours are arranged in Table 4. This information indicates that the least affected of the larvae examined is insect No. 1 and the most severely affected insect is No. 6. These data have been arranged to show how the blood picture is altered as the animals become more affected. On the basis of the hematological data, as shown, insect No. 4 is more affected by ligaturing than the other active, non-necrotic larvae (Nos. 1, 2, and 3). Relative increases in prohemocytoids (I) and smooth contour chromophilic cells (II) indicate a possible regenerative shift, and this seems to be associated with an increase in the total count. However, the increase in the total count is not marked, because the total count in mealworm larvae may normally vary from 20,000 cells to 70,000 cells per cubic millimeter. Nevertheless, the data as they stand seem to indicate a progressively increasing total count. Insect No. 5, which was active, although somewhat necrotic at

TABLE 4

Individual Total and Differential Counts From Anterior End of Larvae Ligated Between Segments 3 and 4, Together With Symptoms; Ligature Time: 120 Hours

Insect No. and Symptoms	I	II	III	IV	VI	VII	VIII	F	Mean THC (Cells/mm^3)
								Percentage	
1. Active, not necrotic at ligature site	0.0	0.0	2.0	47.0	51.0	0.0	0.0	3.0	35,500
2. Same as No. 1	0.0	0.0	0.0	21.0	79.0	0.0	0.0	10.0	39,600
3. Same as No. 1	0.0	2.0	0.0	50.0	48.0	0.0	0.0	12.0	44,500
4. Same as No. 1	1.0	5.0	0.0	25.0	69.0	0.0	0.0	10.0	48,500
5. Active, necrotic at ligature site; blood volume reduced	5.0	0.0	0.0	45.0	50.0	0.0	0.0	30.0	66,000
6. Not active, necrotic at ligature site; dehydrated, blood volume greatly reduced	0.0	0.0	1.0	39.0	60.0	0.0	0.0	65.0	76,000

the ligature site, showed blood volume reduction in comparison to the preceding larvae. This insect showed a marked relative increase in prohemocytoids (I) and a very marked increase in fusiform cells (F), as well as a relatively elevated total count (THC). Insect No. 6, which was feeble and shrunken, had a greatly reduced blood volume. The elevated total count in this insect may be associated with hemoconcentration from severe dehydration. The increase in the fusiform cells (F) is strik-

TABLE 5

Individual Differential Hemocyte Class Counts Made Anterior and Posterior to the Ligation Site in Mealworm Larvae

Ligation Time (Hours)	Sampling Site	Hemocyte Classes (Per Cent)						
		I	II	III	IV	VI	VII	VIII
48	anterior	0.0	0.0	0.0	63.0	5.0	4.0	28.0
	posterior	0.0	0.0	0.0	40.0	60.0	0.0	0.0
96	anterior	0.0	0.0	0.0	37.0	63.0	0.0	0.0
	posterior	0.0	0.0	2.0	65.0	24.0	1.0	2.0
144	anterior	2.0	0.0	1.0	48.0	45.0	4.1	0.0
	posterior	0.0	0.0	0.0	45.0	52.0	1.0	2.0

ing, but its significance is not known. Both differential and total counts were made anterior to the ligature site in the customary manner.

Differential counts made anterior to the ligature site frequently do not agree with counts made posterior to the site, and thus, cannot be compared; see Table 5. Reasons for these differences are not clear.

Desiccation. As shown in Table 6, desiccation does not materially affect the differential hemocyte count in mealworm larvae.

TABLE 6
MEAN DIFFERENTIAL HEMOCYTE COUNTS FROM DESICCATED MEALWORM LARVAE

Desiccation Time (Days)	No. Larvae Used	Hemocyte Classes (Per Cent)							
		I	II	III	IV	VI	VII	VIII	M
									Percentage
7	5	0.4	0.0	0.6	31.6	67.4	0.0	0.0	0.2
14	12	1.3	1.0	0.2	28.8	68.5	0.1	0.0	0.1
30	13	1.8	1.7	1.0	30.2	65.3	0.3	0.2	0.07

Starvation. A series of total hemocyte counts was made from larvae starved for various lengths of time (from 1 to 30 days) as shown in Table 7. None of these larvae showed any marked change in hemocyte numbers. However, larvae subjected to more prolonged starvation (2 months, and as long as 4 months) showed a pronounced tendency to develop a decided hemocytopenia, as judged by the relatively few cells present in stained smears.

Differential hemocyte counts and a few total counts are shown in Table 8. The former counts show a general tendency for the cystocytes (VI) to increase and for the plasmatocytes (IV) to decrease. Lack of nourishment seems to be associated with increases in prohemocytoids (I), smooth contour chromophilic cells (II), and oenocyte-like cells (III), especially when starvation is prolonged.

TABLE 7
TOTAL HEMOCYTE COUNTS FROM STARVED MEALWORM LARVAE

Days Starved	No. Larvae Used	Mean THC (Cells/mm³)
1	3	29,300
2	3	25,500
3	6	30,100
4	5	28,500
5	5	31,000
6	4	34,750
7	5	45,900
8	5	41,500
9	4	36,750
17	12	24,000
30	1	83,750

Data from larvae that were starved and then were allowed access to food for various lengths of time are shown in Table 9. In these larvae there is a tendency for the plasmatocytes to increase, but the total count appears essentially unaffected.

DISCUSSION

Hemorrhage. Recently Beard (3) demonstrated that the Japanese beetle larva can lose 50 per cent or more of its hemolymph without fatal results. He noted a loss of weight greater than that of the hemolymph lost through hemorrhage, a delay in metamorphosis, a temporary

TABLE 8

Mean Differential Hemocyte Counts and THC From Starved Mealworm Larvae

Days Starved	No. Larvae Used	Hemocyte Classes (Per Cent)							M	Mean THC (Cells/mm³)
		I	II	III	IV	VI	VII	VIII		
5	5	0.0	0.0	0.0	60.0	40.0	0.0	0.0	0.0	....
6	4	1.0	0.2	0.7	38.8	59.3	0.0	0.0	0.0	....
7(A)*	9	0.0	0.0	0.0	25.2	74.7	0.0	0.0	0.0	....
7(B)*	17	1.7	0.7	0.4	38.0	57.3	0.7	0.7	0.1	....
7(C)*	4	0.3	1.3	1.0	32.0	65.5	0.0	0.0	0.0	31,550
7(D)*	4	0.0	0.0	1.0	48.3	50.8	0.0	0.0	0.2	....
8	5	0.0	0.4	0.6	44.6	54.6	0.0	0.0	0.0	....
9	4	1.5	0.0	1.3	54.8	42.3	0.0	0.3	0.0	....
14	7	1.7	0.0	0.8	37.0	60.4	0.0	0.0	0.0	....
17	12	0.2	0.0	0.8	43.1	55.6	0.2	0.0	0.0	24,000
30	63	1.7	0.2	0.3	21.5	76.1	0.1	0.2	0.0	....
55	15	1.5	1.0	0.3	27.2	69.6	0.1	0.1	0.0	....
60	10	3.3	0.6	0.5	20.6	73.0	0.0	1.0	0.0	....
120	6†	3.0	3.0	1.5	29.5	62.6	0.0	0.4	0.0	....

* Four sets of larvae were run at different times.

† Out of 10 original larvae, two died, one emerged as an adult, and one was in the pupal stage. Only larval counts are shown.

lowering of hemolymph specific gravity, and a transient decrease in hemolymph potassium.[4] On the other hand, he found that the *p*H of the hemolymph and the total number of hemocytes were unaffected by hemorrhage. In the case of the mealworm larva, it seems unlikely that it could survive a loss of 50 per cent of its hemolymph volume at one time without a fatal outcome. Results from the present study on the

[4] It is logical to suspect that an insect losing 50 per cent of its hemolymph volume would undergo some degree of "shock." If the Japanese beetle larvae were in a state of shock, it is interesting, from the comparative physiology viewpoint, to find a low hemolymph potassium level. Shock in the vertebrates is associated with a high plasma potassium level, although hemorrhage by itself is not associated with an increased plasma potassium. Tobias (36) has shown that muscles and nerves of the roach normally function in the presence of a high serum potassium level.

mealworm are in agreement with Beard's finding in the Japanese beetle in that the total hemocyte count is not pronouncedly affected by a single hemorrhage. Morever, the differential hemocyte count of *T. molitor* is unaffected.

Beadle and Shaw (2) have shown that large and rapid hemolymph chloride changes occur after hemorrhage from *Sialis* larvae. They noted that the hemolymph volume was restored, and that no alteration in total osmotic pressure occurred after hemorrhage.

Cameron (6) studied the effects of hemorrhage in *Galleria mellonella* and in some other Lepidoptera. Twenty-four hours after hemorrhage he found the proportion of "lymphocytes" (probably corresponding to prohemocytoids [I] and smooth contour chromophilic cells [II] of the mealworm) greatly increased. He reported a decrease in "leucocytes" (probably corresponding to the plasmatocytes [IV] of the mealworm), but found the "spherule cells" unaffected. It may be that the "spherule cells" of Cameron correspond to the rhegmatocytes of *Prodenia* (38); they do not appear to correspond to any cell in the mealworm. While Cameron did not find evidence of proliferation of cells lining the hemocoele after hemorrhage, he did note an increase in the number of mitotic figures in the "lymphocytes." In the mealworm there is no unusual increase in prohemocytoids, but there is an increased mitotic count.

TABLE 9

INDIVIDUAL DIFFERENTIAL AND TOTAL HEMOCYTE COUNTS FROM STARVED MEALWORM LARVAE AFTER FEEDING FOR VARIOUS LENGTHS OF TIME

Days Starved	Time With Food	I	II	III	IV	VI	VII	VIII	M	F	CSN	THC (Cells/mm³)
										Percentage		
8.......	1 hr.	2.0	0.0	0.0	43.0	55.0	0.0	0.0	0.0	16.0	40.0	81,000
8.......	1 hr.	0.0	0.0	1.0	48.0	51.0	0.0	0.0	0.0	13.0	34.0	44,500
8.......	2 hr.	0.0	0.0	0.0	40.0	60.0	0.0	0.0	0.0	15.0	30.0	48,000
8.......	2 hr.	0.0	0.0	1.0	26.0	73.0	0.0	0.0	0.0	15.0	15.0	42,500
8.......	3 hr.	0.0	0.0	0.0	35.0	65.0	0.0	0.0	0.0	13.0	......	24,700
8.......	3 hr.	0.0	0.0	1.0	34.0	65.0	0.0	0.0	0.0	24.0	......	43,000
8.......	24 hr.	0.0	0.0	1.0	62.0	37.0	0.0	0.0	0.2	9.0	0.0	41,500
8.......	24 hr.	5.0	0.0	1.0	44.0	50.0	0.0	0.0	0.0	19.0	......	60,200
8.......	24 hr.	0.0	0.0	2.0	45.0	53.0	0.0	0.0	0.0	......	......	49,000
8.......	24 hr.	0.0	0.0	2.0	45.0	52.0	0.0	1.0	0.0	14.0	......	56,500
21.......	1 wk.	1.0	1.0	1.0	50.0	47.0	0.0	0.0	0.4	20.0	21.0	....
21.......	1 wk.	2.0	0.0	2.0	36.0	60.0	0.0	0.0	0.1	0.9	6.0	....

Cautery. Belehradek, in his review on temperature and living matter (4), referred to the following structural changes in cells following exposure to high temperatures: granule formation, surface darkening (in dark field), cytoplasmic vacuolation, protoplasmic contraction, changes

in cell size and shape, "hernial" protrusions, disappearance of mitochondria (in frog hepatic cells and in plant cells), nuclear changes, changes in mitosis, and cytolysis (the final effect). He writes, "Among the various modifications of living systems produceable by heat, there is none which might be said to be exclusively brought about by heat alone" (p. 189).

Jefferson (17) studied the effects of heat injury on the fat cells of *Calliphora* and found through the use of supravital stains that the ordinarily small, discrete, globular mitochondria were generally larger and often clumped in adipose cells of heat injured larvae. He writes, ". . . heat injury is due to the inactivation or destruction of enzymes," and later states ". . . the 'liberation' of mitochondrial lipoids . . . might well result in an upsetting of the enzyme system of the animal and lead to irreversible heat injury." Jefferson considers that damaging of the mitochondria, through heat, inactivates a dehydrogenase system. MacCardle (25), who studied the effects of heat rigor and lethal temperatures in *Fundulus* and the goldfish, described three phases of mitochondrial dissolution: vesiculation, fragmentation, and globulation. According to MacCardle, the dissolution processes resulting from heat are probably the result of changes in cytoplasmic *p*H and are not due to the direct "solvent" action of heat.

Fraenkel and Hopf (11), in studying the effects of abnormally high temperatures on *Calliphora* and *Phormia,* came to the conclusion that a physical breakdown of fatty substances could not be the direct cause of heat injury. Hopf (14) investigated the changes in phosphorus distribution in the hemolymph of heat injured Diptera and noted increases in lipoid phosphorus, and in inorganic and adenylpyrophosphate-P of the hemolymph. Shifts in phosphorus contents are more pronounced after long exposure to lower but eventually lethal temperatures than after a short exposure to high temperatures; however, the adenylpyrophosphate-P increased equally at both extremes.

Although there are a number of studies on the effects of heat on insects [see review by Belehradek (4)], no study on the effects of severe heat injury on the hemocytes has come to the attention of the writers. Iwasaki (15) investigated the effects of increasing temperature on the phagocytic index in *Galleria* and found that heat accelerates phagocytosis. Fenn (10) showed that the rate of phagocytosis was nearly a logarithmic function of the temperature from 0° to 35°C. Wigglesworth (37) examined wound healing following small burns in *Rhodnius.* He noted that only cells in the immediate vicinity were activated, and that there was little epidermal migration or crowding. This was in contrast to reactions in wounds made by incision, after which the activation zone was wide. He further noted that, with burns, localized mitoses occurred seven days later, but that after incisions, mitoses occurred far from the initial site of injury.

In the mealworm the effects of severe cautery are complicated by

profound "shock." The hemocyte picture shows numerous abnormal forms and a low total count (hemocytopenia).[5]

Ligaturing. Most of the ligaturing of insects has been done in studies on hormones, but Yeager and Munson (39) used ligatures in some ingenious toxicological experiments with *Prodenia* for comparing the hematological findings in the poisoned with the unpoisoned portion in the same insect. Their experiments were terminated after a short ligation time. In the mealworm one cannot effectively compare differential hemocyte counts from the posterior with the anterior end because the separated portions have a marked tendency to exhibit unlike differential counts. One end may show a predominantly degenerative phase while the other end may appear normal. Generally, the end anterior to the ligature is less degenerative in its hemocyte reactions than the posterior end; often the anterior end has apparently normal ratios of the various hemocyte classes. Degenerative changes within the various hemocyte classes are, however, usually manifest after 19 hours. One of the findings anterior to the ligature site is a total hemocyte count within the range for unligatured larvae. It seems reasonable to expect the hemocytes to be equally distributed immedately before ligaturing, and one can assume that if the insect were ligatured, the total count per cu. mm. from the anterior part of a ligatured mealworm larvae should be approximately within an expected value of from 20,000 to 70,000 cells per cu. mm. (18, 19). However, the figures in Tables 3 and 4 show counts higher than this range 24 hours after ligation. These counts are interpreted as representing a hemocytosis.

Desiccation. Most of the information on desiccation in insects relates to changes in body weight and metabolism, but apparently no studies have been made to ascertain if the hemocyte picture is altered by drying. One would expect the mealworm, which normally inhabits and prefers a dry environment, to be less affected by desiccation than insects requiring high humidity for survival. For the most part, the hemocyte picture of mealworm larvae is not altered significantly by even prolonged desiccation.

Starvation. The literature on inanition and malnutrition has been extensively reviewed by Jackson (16). Thus, it has been reported that on death from starvation, small fat droplets still occur in the fat cells, blood cells, and blood vessels; and that lymphoid tissue generally atrophies with disappearance of, or changes in, lymphocytes. In the starvation state, lymphocytes are said to have little nucleoplasm and the chromatin fragments simulate mitotic figures. Animals with well-developed lymphatic systems and richly lymphocytic blood are said to be much more resistant to starvation.

[5] Cameron (5), in a study of inflammation in the earthworm, noted after burning that there was a definite increase in the "basophilic type" of coelomic corpuscle, and also noted proliferation of parietal peritoneum with formation of new coelomic corpuscles nearest the site of injury.

Ash (1), in a study of prolonged fasting in man, has written, ". . . The blood as a whole is able to withstand the effects of complete abstinence from food for a period of at least 31 days without displaying any essentially pathological change."

Suzuki (31) found the following changes in starving guinea pigs: (1) increased red corpuscle count, (2) increased hemoglobin, (3) an initial leucopenia due to lymphopenia, and (4) an eosinophilic leucocytosis.

It has been shown by Jordan (20) that in starved *Trituris* (Amphibia) the changes in the blood elements include nuclear enlargement, disturbances in nuclear-cytoplasmic relationships, and sometimes nuclear vesiculation. Smallwood (30), who studied starvation in the fish, *Amia calva,* found that 20 months of starvation resulted in a marked lowering of both red and white cell counts, but in no significant morphological changes. Schaefer (29) found that certain fish developed anemia during hibernation, but the corpuscular count returned to normal in the spring even when food was lacking. After 97 days of starvation, the total red and white counts combined had decreased 85 per cent; after 168 days starvation, the total count had increased from 338,000 to 1,106,200. Gellhorn and Dunn (12) observed that acute starvation in vertebrates produced a definite tendency toward a progressive decrease in the phagocytic index.

Kohering (21) reported that mitochondria decreased or disappeared in the starved insects which she studied. Deevey (7), in a study of the blood cells of the Haitian tarantula, wrote that starvation for a month or more caused the eosinophilic blood cell types to decrease noticeably. Takatsuki (32) showed that the granular amebocytes of the oyster, *Ostrea edulis,* were not decreased by starvation. Lochhead and Lochhead (22) noted that underfeeding and injury in *Artemia* (Crustacea) led to a decrease in the number of blood cells. Taylor (35) wrote that after prolonged subjection to lack of moisture and food the "chromophil" hemocytes of the American roach were the predominant type.

Beadle and Shaw (2) have recently shown that after weeks of starvation the blood chloride is reduced below 0.10 per cent in *Sialis lutaria* larvae.

It is generally considered that survival time of starving animals is largely dependent on the quantity of stored fat (8). It has been demonstrated, for example, that in starved cats, fat decreases most rapidly during the first few days and that large quantities of extracellular water are also lost. Essential tissues are maintained almost until death.

MacLeod (26) made X-ray studies on starving mealworm larvae. During the first week there was a gradual clearing of the alimentary tract. The fore-gut contained gas bubbles; later, bubbles appeared in the hind-gut. At the end of two weeks, the alimentary canal was greatly distended with gas.

Mellanby (27) considered that loss of weight in starving mealworms was due almost entirely to loss of water, and that no correction for

the rate of metabolism was needed. He also reported that during the first week of starvation, mealworms lose water more rapidly than subsequently. He showed that glycogen was reduced after one week's starvation from 2.04 to 0.68 per cent and that after a month's starvation the mealworm lost 50 per cent of available fat. Mellanby reasoned, p. 385, as follows: ". . . when a mealworm is using its food reserves, if it does not evaporate any water its weight will remain practically constant. It is using fat, which alone would give an increase in weight, and carbohydrate, which alone would give a decrease, and the metabolic products of these two main reserves tend to balance each other, so that the decrease in weight of a starving mealworm is almost entirely due to evaporation."

Gilmour (13) found a glycogen decrease of 0.04 mg. per gram of wet tissue per hour, and a total lipid decrease of 0.18 mg. per gram of wet weight per hour in mealworm larvae starved 2.5 hours at 12°C.

Ludwig (23) pointed out that "a stage which is able to survive a relatively long period of starvation is also able to survive a relatively long time following DDT poisoning." Ludwig (24) found a change in protein nitrogen during starvation in grasshopper nymphs.

The present study on the mealworm indicates that short-term starvation does not generally affect, to any appreciable extent, either the total or differential counts, although there is a tendency after very prolonged starvation for mealworms to develop a hemocytopenia, and for the hemocyte picture to show a decrease in plasmatocytes. On resumption of feeding after starvation, there is a marked increase in mitotic figures and in plasmatocytes.

CONCLUSIONS

The present investigations on the hemocyte picture of mealworm larvae are not extensive enough to permit more than tentative suggestions which should be looked upon as first approximations towards more definite conclusions from elaborate studies along these lines.

(1) Total and differential hemocyte counts from mealworm larvae do not appear to be significantly altered by (*a*) single, small, uncomplicated hemorrhages (*b*) desiccation or (*c*) short starvation periods.

(2) Ligatured larvae develop abnormal hemocyte pictures and have increased total counts. Differential counts anterior and posterior to the ligature site tend to differ widely from each other in the same insect.

(3) A state of "shock" after severe cautery is associated with an altered hemocyte picture, particularly in a marked decrease in total counts.

(4) Prolonged starvation (over 60 days) is associated with a decreased total count and by a decrease in plasmatocytes.

(5) Resumed feeding after starvation is associated with an increased mitotic count and with an increase in plasmatocytes. The total count appears essentially normal.

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FLORA OF ALASKA AND ADJACENT PARTS OF CANADA[1]

An Illustrated Descriptive Text of All Vascular Plants Known To Occur Within the Region Covered

PART IX. CICHORIACEAE, ASTERACEAE (COMPOSITAE)

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58. CICHORIACEAE (Chicory Family)

Herbs (in ours) with bitter or milky sap; leaves alternate or basal; flowers all alike, perfect and fertile, in heads with bracts (phyllaries) in 1 to several series, and often with smaller ones at the base; corolla of united petals forming a tube which is split on one side giving rise to a straplike ligule usually 5-toothed at the apex; stamens 5, united by their anthers into a tube around the pistil; style 2-cleft, filiform; ovary 1-celled, becoming an achene. This family is often combined with the *Asteraceae* and known as the *Compositae*.

1A. Pappus none. .... 1. *Lapsana*
2A. Pappus of plumose bristles.
  1B. Receptacle chaffy. .... 2. *Hypochaeris*
  2B. Receptacle naked. .... 3. *Picris*
3A. Pappus of simple bristles.
  1B. Heads solitary on scapes.
    1C. Pappus tawny. .... 4. *Apargidium*
    2C. Pappus white.
      1D. Achenes muricate at apex. .... 5. *Taraxacum*
      2D. Achenes smooth (see also *Taraxacum kamtschaticum*). .... 6. *Agoseris*
  2B. Heads several to many; stems usually leafy.
    1C. Achenes flattened.
      1D. Achenes beakless. .... 7. *Sonchus*
      2D. Achenes beaked. .... 8. *Lactuca*
    2C. Achenes not flattened.
      1D. Flowers whitish. .... 9. *Prenanthes*
      2D. Flowers yellow, rarely pinkish.
        1E. Pappus white. ....10. *Crepis*
        2E. Pappus sordid or tawny. ....11. *Hieracium*

1. LAPSANA L.

Erect branching annuals; leaves dentate or pinnatifid; heads small,

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yellow, slender-peduncled; phyllaries 8 with a short outer series; receptacle flat, naked. (Greek, Lampsana, the name of a crucifer.)

L. communis L. Nipplewort.

Stem paniculately branched, 3–10 dm. tall, pubescent below, glabrous above; heads very numerous, the involucres in fruit 5–6 mm. long.

Introduced in southeast Alaska. Native of Europe.

2. HYPOCHAERIS (Vaill.) L.

Perennials with scapose, often branched stems; leaves mostly basal, those of the stem few and scale-like; heads large, long-peduncled; flowers yellow; receptacle chaffy; achenes 10-ribbed. (Greek, for pigs, which are fond of its roots.)

H. radicata L. Cat's Ears.

Stems 2–4 dm. tall; leaves spreading, oblanceolate to obovate, pinnatifid to dentate, hirsute; heads 25–30 mm. broad; achenes beaked.

Introduced weed, native of Europe.

3. PICRIS L.

Erect, hispid herbs; flowers yellow in rather large heads; principal phyllaries in 1 series, nearly equal, with 2 or 3 series of exterior spreading ones; receptacle flat, short-fibrillate; achenes 5- to 10-ribbed and transversely wrinkled, narrowed at base and summit; pappus of slender plumose bristles. (Greek, bitter.)

P. hieracoides L. ssp. *kamtschatica* (Ledeb.) Hult.

Biennial, up to 1 m. tall, quite densely hispid; leaves lanceolate to oblanceolate, up to 15 cm. long, the lower narrowed into petioles; involucre 12–15 mm. high; phyllaries narrow, strongly setose; achenes bright brownish red. Fig. 951.

Attu Island and East Asia.

4. APARGIDIUM T. and G.

Practically acaulescent plants with fusiform roots; leaves narrow; heads turbinate with scales in 2- or 3-series, borne on scapes; pappus tawny, of barbellate bristles. (Likeness to Apargia.)

A. boreale (Bong.) T. and G.

Scorzonella borealis (Bong.) Greene.

Leaves linear-lanceolate, 1–2 dm. long, entire or with a few teeth; scapes 15–30 cm. tall; flowers yellow; involucres about 12 mm. high, composed of lanceolate scales with prominent midrib; achenes about 6 mm. long with 10 prominent longitudinal ribs.

Prince William Sound to Humboldt Co., Calif. Fig. 952.

5. TARAXACUM Zinn.

Acaulescent biennial or perennial herbs; heads many-flowered, large, borne on slender, hollow scapes; involucres double, the outer of

short phyllaries, the inner of long, linear, erect phyllaries in a single row; flowers yellow (flesh-colored in one species); achenes 4- to 5-ribbed, the ribs usually roughened, the apex prolonged into a slender beak bearing the pappus of capillary bristles. (Derivation from supposed medicinal properties.)

The dandelions are a difficult group. There is much apomixis, i.e., the achenes develop without fertilization. Many of the forms produce no pollen. This apomixis gives rise to numerous distinguishable constant forms. Modern writers on the genus treat these as species. These correspond with cultivated garden varieties rather than with species in the true sense as recognized in most groups. It will be noted that most of these forms are of local or limited distribution. As collections increase more will be found. Dr. Gustaf E. Haglund of the Riksmuseet at Stockholm, Sweden, has done much work on the group as represented in Alaska and Yukon and his treatment is followed here as a matter of convenience rather than approval.

1A. All phyllaries lacking appendages below the apex.
- 1B. Low-growing native species with small heads.
  - 1C. Involucres dilute-green, broad, short; outer phyllaries whitish-green, up to 9 mm. long. . 54. *T. collinum*
  - 2C. Involucre usually blackish-green, narrower, outer phyllaries dark.
    - 1D. Lateral lobes of the leaves more or less retrorse, short, more or less broad, acute. . 52. *T. alaskanum*
    - 2D. Lateral lobes of the middle leaves patent or somewhat attenuate, often with blunt apex or more or less claw-like with rounded corners.
      - 1E. Petioles purple, terminal lobes of leaves short; achenes red, smooth or nearly so. .... 3. *T. kamtschaticum*
      - 2E. Petioles usually pale, terminal lobes of leaves hastate to hastate-triangular; achenes brownish-black with small sharp spines on top. ....55. *T. sibiricum*
- 2B. Taller (15–30 cm. or more) robust introduced species with large heads.
  - 1C. Outer phyllaries broad (4 – 6 mm.) usually more or less patent; petioles wing-margined, pale or slightly rose-colored. ....50. *T. undulatum*
  - 2C. Outer phyllaries narrower (2 – 5 mm. broad) most of them reflexed petioles more or less red-colored.
    - 1D. Outer phyllaries strongly reflexed, more or less whitish green. ....49. *T. retroflexum*
    - 2D. Outer phyllaries obliquely reflexed, grayish-green or more or less red-colored.
      - 1E. Lateral lobes of leaves deltoid with more or less straight upper margin.
        - IF. Lateral lobes of leaves short; outer phyllaries narrow (about 2 mm. broad), strongly radiating. ....51. *T. vagans*
        - 2F. Apex of lateral lobes longer, outer phyllaries broader.
          - 1G. Terminal lobe of inner leaves long, sagittate, outer phyllaries rather short. ....48. *T. decorifolium*
          - 2G. Terminal lobe of inner leaves shorter, broad; outer phyllaries longer. ......46. *T. cinericolor*

2E. Lateral lobes of leaves more or less claw-like with more or less convex upper margin. . 47. *T. dahlstedtii*
2A. At least some of the phyllaries with large or small appendages below the apex.
1B. Achenes small (about 3 mm. long) with narrow cylindrical beak, brownish brick-red. .... 45. *T. scanicum*
2B. Achenes larger, usually with broad beak, only in a few species more or less red.
1C. Achenes blackish or blackish-green with short conical beak; low-growing species.
1D. Involucre rather small (9–14 mm. long, 5–8 mm. broad); achenes totally spinose. .... 2. *T. phymatocarpum*
2D. Involucre larger, achenes more or less smooth at the base. .... 1. *T. hyperarcticum*
2C. Achenes mostly not blackish, beak usually longer; rostrum 2–3 times longer than the achene.
1D. Petioles more or less intensely red-colored.
1E. Low-growing species (about 10 cm. tall); involucres small, at most about 12 mm. in diameter.
1F. Involucres about as long as broad, outer phyllaries narrowly scarious-margined. .... 5. *T. angulatum*
2F. Involucres longer than broad, outer phyllaries lacking scarious margins. ...... 18. *T. festivum*
2.E. Larger species, 15–45 cm. tall; involucres larger.
1F. Achenes more or less red-colored.
1G. Achenes with conic-cylindrical to cylindrical beak about 1.25 mm. long; lateral lobes of leaves more or less dentate .... 24. *T. lateritium*
2G. Achenes with broader, shorter beak; lateral lobes of leaves entire. .... 9. *T. callorhinorum*
2F. Achenes olivaceous to straw-colored to more or less brown.
1G. Robust species, phyllaries without scarious margins. .... 11. *T. chlorostephum*
2G. Medium-sized species; phyllaries with at least narrow scarious margins.
1H. Outer phyllaries cordate to ovate (3–5 x 5–8 mm.). .... 39. *T. pribylofense*
2H. Outer phyllaries ovate to ovate-lanceolate, narrower. .... 23. *T. lacerum*
2D. Petioles only slightly or not at all red-colored.
1E. Small species, less than 10 cm. tall. Scapes of some may elongate in fruit.
1F. Leaves entire with a few small teeth only. .... 42. *T. speirodon*
2F. Leaves more or less lobed.
1G. Lateral lobes narrow, tapering to a patent or forward-turning point. .... 13. *T. demissum*
2G. Lateral lobes short and broad.
1H. Petioles wing-margined. .... 26. *T. leptoglossum*
2H. Petiole narrow, not wing-margined.
1J. Outer phyllaries lacking scarious margins. .... 29. *T. microceras*
2J. Outer phyllaries with distinct although sometimes narrow scarious margins.
1K. Terminal lobe of leaves elongate with ligulate apex. .... 4. *T. andersonii*
2K. Terminal lobe of leaves short.

1L. Involucres about 14 mm. high, blackish-green. .... 27. *T. leptopholis*
2L. Involucres about 11 mm. high, olivaceous-green. .... 31. *T. multesimum*
2E. Larger species with broader heads.
1F. Leaves not lobed.
1G. Petioles more or less broadly wing-margined.
IH. Outer phyllaries narrowly ovate-lanceolate, about as long as the inner ones. .... 20. *T. hypochoeropsis*
2H. Outer phyllaries ovate to ovate-lanceolate, about half as long as the inner ones. .... 19. *T. flavovirens*
2G. Petioles narrow or narrowly wing-margined.
1H. Appendages of outer phyllaries 0.4–0.8 mm. long. .... 21. *T. integratum*
2H. Appendages of outer phyllaries 0.7–1.5 mm. long. .... 41. *T. signatum*
2F. Leaves more or less lobed, or some leaves with tooth-like lobes.
1G. All or most of the ligules involute or more or less canaliculate.
1H. Outer phyllaries 7–9 mm. long, ovate-lanceolate. .... 33. *T. ochraceum*
2H. Outer phyllaries shorter, ovate. ...... 8. *T. caligans*
2G. Ligule more or less flat.
1H. Lateral lobes of leaves narrow to linear.
1J. Outer phyllaries membranous, whitish-green. .... 40. *T. scotostigma*
2J. Outer phyllaries more or less herbaceous, pale green. .... 43. *T. sublacerum*
2H. Lateral lobes of leaves broader.
1J. Lateral lobes of leaves more or less claw-like.
1K. Anthers with pollen, lateral lobes of leaves approximate, entire or very sparsely dentate. .. 22. *T. kodiakense*
2K. Anthers lacking pollen, lateral lobes of leaves less approximate, with larger teeth. .... 35. *T. paralium*
2J. Lateral lobes of leaves deltoid or replaced by short tooth-like lobes.
1K. Outer phyllaries nearly as long as the inner ones, more or less lanceolate.
1L. Leaves narrow, 10–15 mm. wide, lateral lobes few and poorly developed. .... 38. *T. phalolepis*
2L. Leaves broader, lateral lobes more numerous, short, broad. .... 14. *T. dumetorum*
2K. Outer phyllaries much shorter than the inner ones, ovate to ovate-lanceolate.
1L. Outer phyllaries more or less membranous, whitish-green, partly more or less reddish.
1M. Leaves broad, densely rosulate, petioles wing-margined. .... 34. *T. ovinum*

2M. Leaves narrow, not rosulate, petioles narrow. ....53. *T. carneocoloratum*
2L. Outer phyllaries herbaceous.
1M. Outer phyllaries with broad (1 mm.) scarious margins.
1N. Appendages of the outer phyllaries about 1.5 mm. long. ....25. *T. latilimbatum*
2N. Appendages of the outer phyllaries about 0.5 mm. long. ....36. *T. patagiatum*
2M. Outer phyllaries narrowly scarious-margined.
1N. Involucres dark, blackish-olivaceous to blackish-green.
1P. Leaves narrow (5 mm. broad) with weakly developed lateral lobes. ....15. *T. eurylepium*
2P. Leaves broader, lateral lobes short and broad.
1Q. Lateral lobes of the leaves with a somewhat contracted, short apex. .... 6. *T. arietinum*
2Q. Lateral lobes tapering to a short, more or less retrorse apex.
1R. Involucres about 17 mm. high, broad 30. *T. mitratum*
2R. Involucre shorter, fairly narrow. . 28. *T. maurolepium*
2N. Involucres lighter colored, more or less olive-green.
1P. Petioles narrow, somewhat reddish. ..... 7. *T. aureum*
2P. Petioles more or less wing-margined, pale.
1Q. Terminal lobes of leaves small, triangular-rhomboid, often with short acumen.
1R. Leaves dark green 16. *T. eyerdamii*
2R. Leaves light or yellowish green. . 44. *T. trigonolobium*
2Q. Terminal lobes of leaves of medium size, usually more or less sagittate, tapering to the apex or blunt.
1R. Achenes smooth with scale-like spines toward the apex only. 33. *T. oncophorum*
2R. Achenes more spiny.

1S. Achenes large, about 6 mm. long including beak. . . 17. *T. fabbeanum*
2S. Achenes smaller, 4.6 – 4.8 mm. long. . . . . 10. *T. chamissonis*

1. *T. hyperarcticum* Dahlst.

Leaves long-petioled, entire to few sinuate-lobed, 10–20 cm. long; scapes many, rose-violet at the base; involucre 12–15 mm. high; outer phyllaries ovate to ovate-lanceolate, dark green; achenes olivaceous, muricate at top, tuberculate below, about 5 mm. long.

Cape Thompson, Nova Zemla, Greenland.

2. *T. phymatocarpum* J. Vahl.

Leaves small, subentire, sparsely and minutely dentate to briefly lobed; heads 1–3, rarely more; involucre blackish, 9–14 mm. high, 5–8 mm. wide; outer phyllaries ovate; achenes 5 mm. long, about 1.45 mm. wide, muricate at top to tuberculate at base.

Elim and Teller—Greenl.

3. *T. kamtschaticum* Dahlst.

Leaves 1 dm. or less long, lobed, the lobes rounded or obtuse, the petiole reddish-purple; scapes in anthesis low, in fruit up to 15 cm. tall, smooth; involucre olive-green to black-green; outer phyllaries without conspicuous nerves, unappendaged, with entire, greenish, scarious margins. This is easily distinguished from the other species by the chestnut-red achene which is smooth or very nearly so.

From Kamchatka to most of Alaska. Fig. 953.

4. *T. andersonii* Hagl.

Leaves narrow, ligulate lanceolate, dark green, with short, deltoid, lateral lobes, up to 7 cm. long; scapes short at flowering but elongating in fruit to 25 cm.; phyllaries with appendages below the apex, dark green; achenes dark brown, rugulose below and spiny at the top, 4.5–4.9 mm. long.

Skagway and Popoff Isl. of the Shumagin Isls. Fig. 954.

5. *T. angulatum* Hagl.

Low-growing, about 10 cm. tall; leaves 3–7 cm. long, about 1 cm. wide, shallowly lobed, the lobes deltoid; scapes longer than the leaves, subglabrous; involucre about 12 mm. long and broad; outer phyllaries ovate, 4.5–7 mm. long, 2–3 mm. wide, only one or a few provided with appendages; achenes 4.3–4.5 mm. long, tawny-olive, spinulose above.

St. Matthew Isl.

6. *T. arietinum* Hagl.

Plants about 15 cm. tall; leaves about 10 cm. long and 1 cm. wide, sinuate-lobed; scapes slender, nearly glabrous; involucre about 17 mm. high; outer phyllaries loosely appressed, 5–8 mm. long, 2–3.5 mm. wide with appendages 0.5–1 mm. long; achenes 4.7–5 mm. long, with acute spines above and tuberculate.

Alatna River and Richardson Highway between Summit and McCarty.

7. *T. aureum* Hagl.

Plants 2–3 dm. tall; leaves ascending, obovate-oblanceolate, toothed to shallowly lobed, about 12 cm. long and 2 cm. wide; scapes exceeding the leaves; involucre 12–17 mm. high; outer phyllaries ovate, 5–7 mm. long, 2.5–4 mm. wide, with wide scarious margins and appendages up to 1 mm. long.

Teller.

8. *T. caligans* Hagl.

Plant about 1 dm. tall; leaves up to 2 cm. wide, with subtriangular lateral lobes; scapes about equaling the leaves, more or less red-colored; involucres 10–12 mm. high; outer phyllaries ovate, 2–3 mm. wide, 5.5–8 mm. long, with appendages 0.5 mm. long; achenes 5 mm. long, brown.

Tonsina Lodge on Richardson Highway.

9. *T. callorhinorum* Hagl.

Medium size; outer leaves spatulate, sparsely toothed; inner leaves lobed with few triangular lobes; petioles purple; scapes exceeding the leaves; heads dark, almost black, 15–18 mm. high; outer phyllaries ovate to ovate-lanceolate, the margins light rose to purplish; appendages about 0.5 mm. long; achenes red, spiny at top, tuberculate or smooth at base.

St. Paul and Unalaska Isls.

10. *T. chamissonis* Greene, emend Hagl.

Plant with many leaves, about 3 dm. tall; leaves 12–20 cm. long, 2–4 cm. wide, not lobed but deeply and irregularly toothed with backward-pointed teeth; involucre 15–17 mm. high; outer phyllaries cordate to wide-ovate, (2.5–) 4.5 mm. wide, 6–8 mm. long; inner phyllaries with prominent appendages; achenes brown, 4.6–4.8 mm. long, somewhat spinose at top, smooth below.

St. Paul, St. Matthew and Hall Isls.

11. *T. chlorostephum* Hagl.

Plants robust, 25–50 cm. tall; leaves sinuate-lobed, the lobes subtriangular and toothed; outer phyllaries narrowly ovate-lanceolate to

lanceolate, 3–4.5 mm. by 12–15 mm., narrowly white-margined, with appendages 0.5–1.5 mm. long; inner phyllaries sublinear; anthers with scanty pollen; achenes light olive-brown, 5 mm. long, short spinose above.

Eklutna, Kodiak and vicinities.

12. *T. chromocarpum* Hagl.

Leaves blue-green, lobes triangular, entire or minutely denticulate and with rose-colored petioles; outer phyllaries narrowly white-margined; achenes mahogany-red, about 4 mm. long, densely and acutely spinulose at the top.

Unalaska.

13. *T. demissum* Hagl.

Plants small; leaves lanceolate, deeply lobed with 3 or 4 pairs of deltoid lateral lobes, the terminal lobe hastate-sagittate; involucre about 13 mm. high; outer phyllaries ovate or ovate-lanceolate, 2–3 mm. wide, 3–8 mm. long, the appendages 1–2 mm. long.

Hooper Bay.

14. *T. dumetorum* Greene.

Large; leaves up to more than 3 dm. long, oblanceolate, often broadly so, acutish, the margin not deeply, but very unevenly and laciniately cut, the teeth spreading; scapes mostly 3 dm. or more tall; outer phyllaries large, pale and thin, before flowering almost as long as the inner; achenes olive-green, spinulose at the summit, otherwise smooth or the ribs tuberculate.

Ranch Valley, Yukon—Alta.—Wyo.

15. *T. eurylepium* Dahlst.

A small form resembling *T. phymatocarpum* J. Vahl and probably identical with it.

Bering Sea and Arctic Coast regions.

16. *T. eyerdamii* Hagl.

Plant medium in size; leaves slightly to rather deeply lobed, the terminal lobe triangular, the petioles pale red; involucre about 15 mm. high, the scape pubescent below the head; phyllaries light, striate, prominently appendaged; achenes buff, 4.5–5 mm. long, spiny above.

East Aleutians. Fig. 955.

17. *T. fabbeanum* Hagl.

Plant medium, 7–25 cm. tall; leaves rather deeply lobed, the lobes deltoid and usually sharply toothed; involucre 13–19 mm. high; outer

phyllaries 3–4 mm. by 4.5–9.5 mm.; inner phyllaries conspicuously white-margined; achenes olive-brown, 6 mm. long.

St. Paul and St. Lawrence Isls.

18. *T. festivum* Hagl.

Plants small, 5–10 cm. tall; leaves 6–8 cm. long, 5–10 mm. wide, shallowly lobed; scapes more or less curved, sparsely pilose below the head; involucre 10–14 mm. high, black-green; outer phyllaries with small but well-developed appendages.

Point Barrow.

19. *T. flavovirens* Hagl.

Plants 15–35 cm. tall, not robust; leaves thin, yellow-green, obovate-oblong or oblong, 5–10 (–20) cm. long, the margins toothed; scapes 1 or few; involucre olive-green, about 16 mm. high; outer phyllaries lighter green than the inner ones, with broad white scarious margins, one or a few with appendages; achenes about 3.5 mm. long, sharply muricate.

Haines, Whitehorse and B.C.

20. *T. hypochoeropsis* Hagl.

Plant tall; leaves obovate-oblanceolate, broad, not lobed, some with prominent teeth; involucre about 25 mm. broad, light green; outer phyllaries long, some with appendages; anthers without pollen; achenes light brownish-olive, about 4 mm. long, short-spinose at top, rugulose below.

Anchorage.

21. *T. integratum* Hagl.

Plants up to 25 cm. tall; leaves oblong-oblanceolate, 4–13 cm. long, 5–15 mm. wide, sinuate-dentate; involucre 12–15 mm. high; outer phyllaries ovate or ovate-lanceolate, 2–3.5 mm. wide, 6–7 mm. long, white-margined; anthers without pollen; achenes umber, 4.7–5 mm. long, short spinulose above, rugulose below.

St. Michael, Teller, Pt. Lay and Camden Bay. Fig. 956.

22. *T. kodiakense* Hagl.

Plants 5–20 cm. tall; leaves light green, up to 3 cm. wide with few short lateral lobes; terminal lobe ovate-triangular, short-acuminate; petiole pale, wide-winged; involucre medium-sized, fleshy, olive-green; outer phyllaries ovate to ovate-lanceolate, 1.5–4 mm. wide, 6–10 mm. long with appendages 1–1.5 mm. long; anthers bearing pollen.

Kodiak Island.

23. *T. lacerum* Greene.

Medium size, the scapes in fruit up to 40 cm. tall; leaves deeply

pinnatifid, the narrow acute lobes usually sharply deflexed backward; heads several to many, large; nearly all phyllaries with corniculate appendages; achenes about 4 mm. long, spinulose at apex to nearly smooth at base.

Widely distributed, Bering Sea—Arctic Isls.—Labr.—Newf.—Alta. Fig. 957.

24. *T. lateritium* Dahlst.

Outer leaves merely dentate, the inner sinuate-lobed, the lobes toothed; scapes 1–3, pale below, copper-colored above; involucre 13–15 mm. high, fuscous or blackish-green; outer phyllaries wide-ovate-lanceolate, the appendages small; achenes 3.5–4 mm. long, spinulose toward the apex, the pyramid prominent.

Bering Sea and Arctic Coast districts. Fig. 958.

25. *T. latilimbatum* Hagl.

Plants about 35 cm. tall; leaves long, about 2 cm. wide, remotely sinuate-dentate to sinuate-lobed with long pale petioles; involucre about 15 mm. high, pale olive-green; outer phyllaries ovate to ovate-lanceolate with appendages 1.5 mm. long; anthers without pollen; achenes honey yellow, about 4.5 mm. long, tuberculous-rugulose with a few spines on top.

Black Hill Creek, Yukon.

26. *T. leptoglossum* Hagl.

Plant small, 10–15 cm. tall; leaves many, up to 5 or 6 cm. long with a few broad lateral lobes and ligulate terminal one; involucre 10–12 mm. high, light green; outer phyllaries ovate-lanceolate, some with appendages; achenes dark straw-yellow, the top minutely but sharply spiny, more or less tuberculate below.

Karluk, Kodiak Isl.

27. *T. leptopholis* Hagl.

Plant small, about 10 cm. tall; leaves more or less prostrate, with 4–6 approximate and short lateral lobes; scapes fairly villous; involucre about 14 mm. high; outer phyllaries margined, the appendages small, black; achenes spiny at top, otherwise nearly smooth.

Glacier and Yakutat bays.

28. *T. murolepium* Hagl.

Plants 10–25 cm. tall; leaves narrowly lanceolate, long, 1–2 cm. wide, light green, sinuate-lobed, the lobes small, subtriangular; involucre about 14 mm. high, dark olive-green; outer phyllaries ovate, 3–5 mm. wide, 8–10 mm. long, white-margined, the appendages 0.5–2.5 mm. long; achenes 4–4.5 mm. long, short-spiny on top, rugulose below.

Umiat and Shaktolik.

29. *T. microceras* Hagl.

Plant small; leaves 3–5 cm. long, 5–15 mm. wide, the outer not lobed, the inner with a few short deltoid lobes; involucre about 13 mm. high, olive-green; outer phyllaries ovate-lanceolate, 1–2 mm. wide, 4–6 mm. long, the appendages small; achenes umber-brown, 4–4.5 mm. long with short, fine spines at top, tuberculate or the base smooth.

Worthington Glacier near Valdez.

30. *T. mitratum* Hagl.

Medium size; leaves lanceolate, the terminal lobe large, hastate-sagittate or sagittate, the lateral lobes deltoid, broad; involucre about 17 mm. high, blackish-green; outer phyllaries with broad white margins, provided with 1–2 mm. long appendages; achenes olive-ochre, 4.9 mm. long, spines small, tuberculate-rugulose, smooth toward the base.

Katmai region and Hope on Kenai Penin.

31. *T. multesimum* Hagl.

Plant low, 5–8 cm. tall; leaves about 5 cm. long, 5–15 mm. wide with lateral lobes approximate, deltoid; terminal lobe triangular-hastate; involucre about 11 mm. high; outer phyllaries 1.5 mm. wide, 4–5 mm. long, white-margined, one or a few with small appendages; anthers without pollen.

Moose Pass in Kenai Penin.

32. *T. ochraceum* Hagl.

Plants medium, 10–20 cm. tall; leaves many, long, narrow, with claw-like or deltoid lobes and prolonged terminal lobe; involucre olive-green, 15–18 mm. high; outer phyllaries ovate-lanceolate, scarious-margined, with appendages below the apex; achenes brownish, short-spiny on top, tuberculate or smoothish at the base, 4.5 mm. long.

Tonsina Lodge and Gulkana on Richardson Highway.

33. *T. oncophorum* Hagl.

Plant medium; outer leaves toothed, inner leaves with deltoid lateral lobes usually not opposite; terminal lobe small; involucre olive-green, about 13 mm. high; outer phyllaries ovate to ovate-cordate, 3–4 mm. wide, 5–8 mm. long; anthers without pollen; achenes light-colored, 4.1–4.5 mm. long, shortly and sparsely muricate at top, otherwise quite smooth.

Attu Island.

34. *T. ovinum* Greene emend Hagl.

Plants small, up to 20 cm. tall; leaves light yellowish green, somewhat decumbent, often only sinuate-dentate or sinuate-lobed, the lobes triangular; involucre medium, 12–15 mm. high; outer phyllaries ovate-

lanceolate with fairly small appendages; anthers with pollen; achenes brown, spinulose at top, smooth at the base.

Ranch Valley, Yukon to B. C. and Alta.

35. *T. paralium* Hagl.

Plants 1–2 dm. tall; leaves 5–10 cm. long, about 2 cm. wide; lateral lobes 3–4 on each side, deltoid, short claw-like; involucre about 1 cm. high; outer phyllaries ovate-lanceolate, 1–2 mm. wide, 6–7 mm. long, pale yellow-green, conspicuously margined, with appendages about 1 mm. long; achenes brown, 5 mm. long, short-spinulose at top.

Anchorage and Kenai.

36. *T. patagiatum* Hagl.

Plants 7–15 cm. tall; leaves light green with fairly triangular, short lateral lobes and hastate terminal lobe; petioles pale; involucre about 15 mm. high, light green; outer phyllaries ovate, 2–4.5 mm. wide, 5–8 mm. long, with appendages up to 1 mm. long; achenes 5 mm. long, tuberculate with spinose tip.

Seward—Fairbanks—Coal Cr. in east Alaska.

37. *T. pellianum* Porsild.

Plant small; leaves glabrous, firm, bright green excepting the purplish midrib, lanceolate, subentire, 6–8 cm. long when mature, 8–10 mm. wide; scapes 8–10 cm. tall; involucre about 15 mm. high, olive-green; tips of the phyllaries distinctly corniculate; anthers dark yellow, containing pollen; achenes dark straw-colored, the tips spiny, 4.24 mm. long.

Pelly Mts.

38. *T. phalolepis* Hagl.

Plants about 15 cm. tall; leaves about 10 cm. long, 10–15 mm. wide, firm, glabrous, entire to sinuately lobed, the lobes short and few; involucre olive-green, about 16 mm. high; outer phyllaries long with rather large appendages; anthers without pollen.

Chitina River Glacier.

39. *T. pribilofense* Hagl.

Plants 2–3 dm. tall; leaves from sharply toothed to moderately deeply lobed, the lobes subtriangular, acute, tooth on upper edge; petioles reddish-purple; involucre about 16 mm. high, light olive-green; outer phyllaries 3–5 mm. wide, 5–8 mm. long; appendages up to 1.5 mm. long; anthers with little pollen; achenes brown, 5–5.5 mm. long, spinulose at top, slightly tuberculate.

St. Paul Isl.

40. *T. scotostigma* Hagl.

Plants about 20 cm. tall; leaves light green, more or less lobed,

the lateral lobes with fairly long patent points; involucre 11–13 mm. high; phyllaries dirty yellowish-green, membranous, with scarious margins and acute corniculate appendages; anthers and stigmas black-green; achenes cinnamon-buff, 4.5 mm. long, squamulose.

Gakona, Tanacross and Fairbanks. Fig. 959.

41. *T. signatum* Hagl.

Plant medium; leaves narrowly oblong-lanceolate, about 1 cm. wide, dentate but not lobed; involucre about 13 mm. high, olive-green; outer phyllaries 1.5–2.5 mm. wide, 5–7.5 mm. long, narrowly but distinctly white-margined and with wide appendages; achenes isabella color, 5 mm. long, short-spiny on top, tuberculate.

Skagway.

42. *T. speirodon* Hagl.

Plant low, 5–15 cm. tall; leaves about 5 mm. rarely up to 1 cm. wide, entire or with a few teeth; involucre about 10 mm. high, black-green; outer phyllaries 5–8 mm. long, 1–3 mm. wide with rather small appendages; achenes olive-buff, 5–5.5 mm. long, squamulate to tuberculate entire length.

Point Hope and Port Clarence region.

43. *T. sublacerum* Hagl.

Plants 1–3 dm. tall; leaves light green, lobulate-dentate to short-lobed; involucre 10–14 mm. high. Resembles *T. lacerum* but has lighter heads with lighter, conspicuously scarious-margined outer phyllaries; the achenes are narrower and the lateral lobes of the leaves are shorter and broader.

Fairbanks—Big Delta—Glenallen—Tacotna.

44. *T. trigonolobium* Dahlst.

Leaves light green with approximate short, wide, more or less triangular lobes, the terminal lobe small, mucronate; scapes many; involucre 10–14 mm. high, blackish-green; outer phyllaries ovate-triangular to ovate-lanceolate, somewhat calloused, the inner phyllaries corniculate; anthers without pollen.

Kamchatka—Aleutians—Kenai. Fig. 960.

45. *T. scanicum* Dahlst.

Leaves glabrescent-green, many-lobed, the lobes spreading, toothed; outer phyllaries long, narrowly lanceolate to linear-lanceolate, callose below the apex or a few corniculate; achenes acute spinulose at apex, short-spinulose to tuberculate below, about 3 mm. long, 1 mm. wide, the pyramid 1 mm. long.

Introduced, Anchorage and Fairbanks.

46. *T. cinericolor* Hagl.

Medium, about 2 dm. tall; leaves gray-green, with long, patent lateral lobes separated by narrow interlobes, the terminal lobes small; involucre 16–19 mm. high, olive-green; outer phyllaries spreading or reflexed, lanceolate, often purple; achenes olive-ochre, 3.8–4 mm. long, spiny at top, somewhat tuberculate to smooth at the base.

Introduced, Skagway, Juneau, Lake Bennett, Unalaska.

47. *T. dahlstedtii* Lindb. f.

A vigorous weed; lobes of the leaves more or less claw-like with convex upper margin; outer phyllaries obliquely reflexed. This is one of the group of European dandelions introduced in America.

Orca and King Cove.

48. *T. decoraifolium* Hagl.

Medium to about 3 dm. tall; leaves cobwebby pilose on midrib, the lateral lobes deltoid, spreading, toothed; outer phyllaries spreading to subreflexed, (2.5–) 4 mm. wide, about 11 mm. long; anthers polliniferous; achenes 3.8–4.1 mm. long, minutely spiny at top, tuberculate, smooth at base.

Introduced type but known only from Juneau.

49. *T. retroflexum* Lindb. f.

Plant vigorous; leaves with petioles up to 3 dm. long, deeply lobed, the lobes triangular, acute, sharply toothed; petioles rose-purple at base; involucres up to 20 mm. high; outer phyllaries strongly reflexed; achenes 3.5 mm. long.

Introduced weed in many parts of Alaska.

50. *T. undulatum* Lindb. f. & Markl.

This is another one of the weedy European species. The broad outer phyllaries are spreading, not strongly reflexed.

In America known only from Juneau.

51. *T. vagans* Hagl.

Plants up to about 35 cm. tall; leaves light green, up to 4 cm. wide and 30 cm. long, sparsely cobwebby, mostly deeply lobed, the lobes dentate; involucre 17–20 mm. high; outer phyllaries subreflexed, about 2 mm. wide, 10–15 mm. long, acuminate; achenes 3.5 mm. long, spinulose on top, tuberculate, smooth at base.

The commonest of our introduced dandelions, Nome and Unalaska east and south.

52. *T. alaskanum* Rydb.

Leaves 3–5 cm. long, deeply runcinate-pinnatifid with triangular

retrorse lobes; scapes 4–5 cm. tall; phyllaries fuscous, not corniculate, the inner linear-lanceolate, long-acuminate, the outer scarcely half as long, lanceolate, spreading or somewhat reflexed; achenes brownish, spinulose-muricate above, 4 mm. long.

Alaska Range, Bering Sea and Arctic. Fig. 961.

53. *T. carneocoloratum* A. Nels.

Taproot short with 1 or more crowns each with several leaves and 1 or 2 scapes; leaf blades 3–6 cm. long, 10–15 mm. wide with 3–6 pairs of subacute and more or less triangular teeth; scapes 10–15 cm. tall; heads rather large; outer phyllaries in 2 series, at first erect, later spreading; inner phyllaries margined, slender-corniculate, green becoming pink; flowers definitely flesh-colored; achenes 4 mm. long, spinulose-muricate at top only.

Mt. McKinley Park.

54. *T. collinum* DC.

Leaves spatulate-oblong, runcinate-dentate; scapes exceeding the leaves; outer phyllaries ovate-lanceolate, not corniculate, subvillous on the margins; achenes spinulose-muricate at apex.

Asia and Unalaska.

55. *T. sibiricum* Dahlst.

Leaves 5–10 cm. long, pale green, deeply runcinate-lobed, the lobes toothed; involucres 12–15 mm. high, more or less blackish-green; outer phyllaries ovate, somewhat acuminate; anthers polliniferous; achenes 3.5–4 mm. long, sparingly short-spinulose at top.

Canol Road, Chickaloon, Nome, Teller and in Asia.

6. AGOSERIS Raf.

Acaulescent perennials with strong taproot; involucral bracts imbricated in a few series, the outer broader and shorter; achenes 10-ribbed, narrowed above into a beak; pappus of numerous white capillary bristles. (Greek, goat and chicory.)

1A. Beak equaling or exceeding the body of the achene. . .1. *A. gracilens*
2A. Beak shorter than the body of the achene.
  1B. Ligulae yellow. ....2. *A. scorzoneraefolia*
  2B. Ligulae orange, turning purplish. ....3. *A. aurantiaca*

1. *A. gracilens* (Gray) Ktze.

Leaves oblanceolate to nearly linear, usually entire or some with a few short lobes, 1–2 dm. long; scapes slender, 1–4 dm. tall, villous below the head; heads 18–20 mm. high, the phyllaries linear-lanceolate; flowers orange, turning purple.

Skagway, B. C.—Alta.—Ida.—Utah—Calif.

2. *A. scorzoneraefolia* (Schrad.) Greene.

Leaves oblanceolate or linear-oblanceolate, glabrous, 1–3 dm. long, entire or rarely denticulate; scapes 1–2 (–3) dm. tall, villous under the head; involucres 2–3 cm. high, the phyllaries broadly lanceolate, acute, villous-ciliate; flowers light yellow turning pinkish in age.

Yukon boundary—Alta.—S. Dak.—Colo.—Nev.—Ore. Fig. 962.

3. *A. aurantiaca* (Hook.) Greene.

Leaves oblanceolate, entire, dentate or lobed; scapes 2–6 dm. tall, villous under the head; involucres 15–20 mm. high; inner phyllaries lanceolate and acute, the outer phyllaries villous; flowers orange turning purple.

Southeast Alaska—Alta.—Colo.—Utah—B.C. Fig. 963.

7. SONCHUS (Tourn.) L.

Introduced weeds; stems leafy; flowers yellow; involucre campanulate with long inner and short outer phyllaries; achenes flattened, ribbed, not beaked; pappus of numerous white capillary bristles. (Greek name of the Sow-Thistle.) The species of *Sonchus* are native of Europe and introduced in many parts of the world but not yet common in Alaska.

1A. Perennial; expanded heads 4–5 cm. wide ....1. *S. arvensis*
2A. Annual; heads smaller.
  1B. Leaves lyrate-pinnatifid, achenes transversely wrinkled. ....2. *S. oleraceus*
  2B. Leaves not deeply pinnatifid; achenes not wrinkled.3. *S. asper*

1. *S. arvensis* L. — Field Sow-Thistle.

Stems 5–11 dm. tall; lower leaves runcinate-pinnatifid, 15–25 cm. long, the base auricled and clasping; heads 2 cm. high, 3–5 cm. broad when expanded; achenes oblong, slightly flattened and with thick ribs.

2. *S. oleraceus* L. — Common Sow-Thistle.

Tall and glabrous; lower leaves petioled, the upper clasping and with pointed auricles, lyrate-pinnatifid, the lobes spinulose-dentate; achenes 3-ribbed and transversely roughened. Fig. 964.

3. *S. asper* (L.) All. — Spiny Sow-Thistle.

Stems tall and glabrous; lower leaves spatulate or obovate, the upper lanceolate with auricled clasping base, spinulose-denticulate on the margins; achenes flattened, 3 mm. long, smooth. Fig. 965.

8. LACTUCA (Tourn.) L.

Tall leafy-stemmed herbs with alternate leaves; heads in panicles, cylindric, becoming conical in fruit; phyllaries imbricated in about 3

series; achenes flattened, contracted into a beak at the apex; pappus of numerous capillary bristles. (From lac, milk, on account of the milky juice.)

1A. Pappus brown. ....1. *L. spicata*
2A. Pappus white.
  1B. Flowers blue. ....2. *L. tartarica*
  2B. Flowers yellow. ....3. *L. virosa*

1. *L. spicata* (Lam.) Hitchc. Tall Blue Lettuce.

Tall, glabrous annual or biennial; leaves deeply pinnatifid, hispid on the veins beneath; heads numerous; flowers blue; achenes flat with short, stout beak.

Southeast Alaska—Newf.—N. Car.—Colo.—Ore. Fig. 966.

2. *L. tartarica* (L.) C. A. Mey. Large-flowered Blue Lettuce.
L. pulchella (Pursh) DC.

Glabrous, leafy perennial, 3–10 dm. tall; leaves linear-lanceolate, lanceolate or oblong, acute, entire to dentate or pinnatifid, 5–20 cm. long; panicle usually narrow; heads 15–20 mm. high.

Yukon Valley—Gt. Bear Lake—Mich.—Mo.—N. Mex.—Calif.

3. *L. virosa* L. Prickly Lettuce.

Biennial with erect stem 5–20 dm. tall; leaves oblong or oblanceolate, spinulose-margined, denticulate or somewhat pinnatifid, 1–3 dm. long, those of the stem auriculate-clasping; heads numerous, the involucres about 1 cm. long.

Introduced at Manly Hot Springs, native of Europe.

9. PRENANTHES L.

Perennial herbs; leaves alternate, dentate, lobed or pinnatifid; heads rather small; flowers white, yellowish or purplish; involucre cylindric, the phyllaries in 1 or 2 series with smaller ones at the base. (Greek, drooping blossom.)

P. alata (Hook.) Dietrich. Rattlesnake Root.
P. lessingii Hult. *Nabalus hastatus* (Less.) Heller.

Somewhat pubescent, 2–4 dm. tall; leaves hastate-deltoid, sharply toothed, with margined petiole; main phyllaries lanceolate, about 1 cm. long; pappus of numerous rather stiff light reddish-brown bristles.

Aleutians—Prince William Sd.—Ida.—Ore. Fig. 967.

10. CREPIS L.

Annual or perennial herbs; leaves entire, toothed or pinnatifid; heads small or medium; flowers yellow or orange; phyllaries in 1 series

with smaller ones at the base; pappus of white slender capillary bristles. (Greek, sandal, application not explained.)

1A. Achenes slightly dilated at the insertion of the pappus; low plants with numerous heads.
  1B. Achenes conspicuously beaked; stems 1 – 2 dm. tall. 1. *C. elegans*
  2B. Achenes scarcely beaked; stems less than 5 cm. tall. 2. *C. nana*
2A. Achenes not dilated at the insertion of the pappus; plants taller. .... 3. *C. capillaris*

1. *C. elegans* Hook.
Youngia elegans (Hook.) Rydb.

Perennial; stem branched, glabrous, 8–20 cm. tall; leaves entire to sinuately pinnatifid with triangular lobes, the cauline lance-linear; heads about 8 mm. high; achenes about 4 mm. long.

Central Alaska—Mack.—Sask.—Wyo.—B.C. Fig. 968.

2. *C. nana* Rich.
Youngia nana (Rich.) Rydb.

In low, dense, sometimes almost stemless tufts; leaves mostly basal, ovate or spatulate, entire, repand-dentate or lyrate; involucre of 8–10 phyllaries 8–10 mm. high and thickened on the backs at the base; achenes cylindric, 5 mm. long, slightly narrowed above, minutely roughened.

Asia—Alaska—Victoria Isl.—Baffin Isl. — Newf. — Colo. — Nev.—Calif. Fig. 969.

3. *C. capillaris* (L.) Wallr.

Annual introduced weed, 3–8 dm. tall; leaves oblanceolate, mostly more or less lacinate-pinnatifid, those of the stem clasping with auriculate base; heads numerous, 8–10 mm. high.

Native of Europe.

11. HIERACIUM (Tourn.) L.

Hairy perennial herbs; leaves entire or dentate, abundant at the base but usually few on the stems; involucre cylindric or campanulate with the bracts in 2 or 3 series and a few small ones at the base; achenes cylindric, 10- to 15-ribbed; pappus of 1 or 2 series of sordid or brownish capillary bristles. (Greek, hawk, from the supposition that hawks used the plants to strengthen their eyesight.)

1A. Involucre bracts of the rather large heads more or less imbricate. .... 4. *H. canadense*
2A. Involucral bracts of the small heads of almost a single series with small calyculate ones below.
  1B. Flowers white; heads several to many. .... 1. *H. albiflorum*
  2B. Flowers yellow, heads few, about 8 mm. high.
    1C. Heads somewhat glandular and short-hairy....... 2. *H. gracile*
    2C. Heads densely wooly. .... 3. *H. triste*

1. *H. albiflorum* Hook. White Hawkweed.

Stems 3–6 dm. tall, long hairy below, glabrate above; upper part of stem nearly naked; lower leaves narrowing into a winged petiole, the upper much reduced; phyllaries long and narrow.

Southeast Alaska and Yukon—Sask.—Colo.—Calif. Fig. 970.

2. *H. gracile* Hook. Slender Hawkweed.

Stems 1–4 dm. tall; leaves spatulate or oblong, glabrate, repand-denticulate or entire; peduncles and involucre black-hairy but hairs much shorter than in *H. triste*. Our form is less glandular than the type and has been described as var. *alaskanum* Zahn. A vigorous form with stems 3–4 dm. tall and bearing 10–15 or more subumbellate heads on long, slender black-villous peduncles is the var. *yukonense* Porsild.

Alaska—Gt. Bear Lake—Alta.—N. Mex.—Calif. Fig. 971.

3. *H. triste* Cham. Wooly Hawkweed.

Stems 1–3 dm. tall; leaves obovate or spatulate, entire, glabrate or sparsely hairy; involucres and peduncles densely covered with long, dark gray or brownish wool. The var. *tristeforme* Zahn approaches *H. gracile* and may be a hybrid with that species.

East Asia—Aleutians—southeast Alaska. Fig. 972.

4. *H. canadense* Michx.

Stems erect, leafy, simple or branched above, 3–10 dm. tall; lower leaves oblanceolate, the upper lanceolate, 3–10 cm. long, sessile, distinctly dentate; involucre 10–12 mm. high; phyllaries glabrous and somewhat blackish.

Near Yukon boundary—Labr.—Penn.—Iowa—Ore.

59. ASTERACEAE (Aster Family)

Herbs (in ours, further south some are shrubs or trees) with various leaves but without stipules; flowers in heads subtended by an involucre of few to many bracts (phyllaries) arranged in one to many series; calyx tube completely adnate to the ovary, its limb when present forming the pappus; corolla tubular, usually 5-lobed or 5-cleft, or that of some marginal flowers expanded into a ligule and forming the ray flowers, which when present make the heads radiate as distinguished discoid heads where the rays are absent; stamens usually 5, borne on the corolla and alternate with its lobes; ovary 1-celled, developing into an achene; style of fertile flowers 2-cleft. An immense family usually divided into tribes only about half of which are represented in our territory. This group is also known as *Carduaceae* and is often combined with the *Cichoriaceae* and known as *Compositae*. The name *Asteraceae* can also be applied to the combined group.

KEY TO THE TRIBES

1A. Anthers caudate at the base; rays none.
  1B. Anthers unappendaged at the tip; heads small. .... 2. *Inuleae*
  2B. Anthers with elongated appendages at tip; heads large. .... 6. *Cynareae*
2A. Anthers not caudate at base; heads usually with ray flowers.
  1B. Receptacle naked.
    1C. Bracts of the involucre usually well imbricated. .. 1. *Astereae*
    2C. Bracts little or not at all imbricated. .... 5. *Senecioneae*
  2B. Receptacle chaffy.
    1C. Bracts of the involucre dry and scarious. .... 4. *Anthemideae*
    2C. Involucral bracts herbaceous. .... 3. *Heliantheae*

1. ASTEREAE

1A. Pappus wanting or of a few capillary bristles. .... 1. *Bellis*
2A. Pappus of capillary bristles.
  1B. Ray flowers yellow.
    1C. Leaves mostly basal. .... 2. *Haplopappus*
    2C. Stems leafy. .... 3. *Solidago*
  2B. Ray flowers not yellow.
    1C. Phyllaries in 2–5 series. .... 4. *Aster*
    2C. Phyllaries in 1 or 2 series. .... 5. *Erigeron*

2. INULEAE

1A. Heads all fertile. .... 8. *Gnaphalium*
2A. Heads dioecious or nearly so.
  1B. Phyllaries in 2–5 series. .... 6. *Antennaria*
  2B. Phyllaries in many series. .... 7. *Anaphalis*

3. HELIANTHEAE

1A. Heads with ray flowers. ....10. *Helianthus*
2A. Heads without rays or rays inconspicuous.
  1B. Pappus none. .... 9. *Madia*
  2B. Pappus of 2 or 4 barbed awns. ....11. *Bidens*

4. ANTHEMIDEAE

1A. Heads radiate (rays usually white).
  1B. Receptacle chaffy.
    1C. Rays short, 2–5 mm. long. ....12. *Achillea*
    2C. Rays 1 cm. or more long. ....13. *Anthemis*
  2B. Receptacle naked.
    1C. Phyllaries in several series. ....14. *Chrysanthemum*
    2C. Phyllaries in few series. ....15. *Matricaria*
2A. Heads discoid.
  1B. Heads small in spike-like or racemose-paniculate inflorescences. ....16. *Artemisia*
  2B. Heads solitary or corymbose.
    1C. Receptacle conical. ....15. *Matricaria*
    2C. Receptacle flat or convex.
      1D. Achenes sessile. ....17. *Tanacetum*
      2D. Achenes raised on pedicels which remain attached to the receptacle. ....18. *Cotula*

5. SENECIONEAE

1A. Leaves all basal; flower heads on scapes. ....19. *Petasites*
2A. Leaves mostly opposite; flowers yellow. .... 20. *Arnica*
3A. Leaves alternate.
  1B. Heads discoid. ....21. *Cacalia*
  2B. Heads usually with ray flowers. ....22. *Senecio*

6. CYNAREAE

Leaves prickly. ....24. *Cirsium*
Leaves not prickly. ....23. *Saussurea*

ARTIFICIAL KEY

1A. Heads radiate.
  1B. Rays yellow.
    1C. Pappus of capillary bristles.
      1D. Leaves opposite. ....20. *Arnica*
      2D. Leaves alternate.
        1E. Phyllaries in 2–4 series. .... 3. *Solidago*
        2E. Phyllaries in 1 series with a few smaller basal ones.
          1F. Phyllaries broad. .... 2. *Haplopappus*
          2F. Phyllaries narrow. ....22. *Senecio*
    2C. Pappus not of capillary bristles.
      1D. Pappus of 2 scales. ....10. *Helianthus*
      2D. Pappus of 4 retrorsely barbed awns. ....11. *Bidens*
      3D. Pappus none or a mere crown.
        1E. Leaves linear and simple. .... 9. *Madia*
        2E. Leaves 1- to 3-pinnately compound. ....17. *Tanacetum*
  2B. rays not yellow.
    1C. Pappus of capillary bristles.
      1D. Rays inconspicuous, stems scapose ....19. *Petasites*
      2D. Rays conspicuous.
        1E. Rays in more than 1 row; phyllaries in 1 row or series. .... 5. *Erigeron*
        2E. Rays in 1 row, phyllaries in several series. .. 4. *Aster*
    2C. Pappus none or a mere crown.
      1D. Leaves entire.
        1E. Acaulescent. .... 1. *Bellis*
        2E. Stem leafy. ....14. *Chrysanthemum*
      2D. Leaves lobed or divided.
        1E. Rays 2–4 mm. long. ....12. *Achillea*
        2E. Rays longer.
          1F. Leaves toothed or lobed. ....14. *Chrysanthemum*
          2F. Leaves dissected.
            1G. Receptacle chaffy. ....13. *Anthemis*
            2G. Receptacle naked. ....15. *Matricaria*
2A. Heads discoid.
  1B. Pappus of capillary bristles.
    1C. Leaves prickly. ....24. *Cirsium*
    2C. Leaves not prickly.
      1D. Receptacle bristly or chaffy. ....23. *Saussurea*
      2D. Receptacle naked.
        1E. Stem scape-like. ....19. *Petasites*
        2E. Stem leafy.
          1F. Wooly plants.
            1G. Heads all fertile. .... 8. *Gnaphalium*
            2G. Heads dioecious or nearly so.
              1H. Phyllaries in 2–5 series. .... 6. *Antennaria*
              2H. Phyllaries in many series. .... 7. *Anaphalis*
          2F. Plants not wooly.
            1G. Flowers white. ....21. *Cacalia*
            2G. Flowers yellow. ....22. *Senecio*
  2B. Pappus not of capillary bristles.
    1C. Receptacle bristly.
      1D. Pappus of 4 retrorsely barbed awns. ....11. *Bidens*
      2D. Pappus none or a mere crown. ....16. *Artemisia*
    2C. Receptacle naked.
      1D. Achenes borne on persistent pedicels. ....18. *Cotula*
      2D. Achenes not on pedicels.

1E. Heads small in spike-like or racemosely-paniculate inflorescence. .... 16. *Artemisia*
2E. Heads larger. .... 15. *Matricaria*

1. BELLIS (Tourn.) L.

Tufted; leaves all basal; phyllaries imbricated in 1 or 2 series, nearly equal; receptacle convex (or conic), naked; ray flowers pistillate, white, pink or purplish; disk flowers yellow, perfect, the corollas tubular with a 4- to 5-toothed limb; achenes obovate, flattened; pappus none or a ring of minute bristles. (Latin, pretty.)

B. perennis L. European Daisy.

Leaves obovate, obtuse, slightly toothed, narrowed into a margined petiole; scapes 5–25 cm. tall bearing a single head; ray flowers numerous, linear.

Occasionally escaped from gardens; native of Eurasia.

2. HAPLOPAPPUS Endl.

Low perennials with caespitose, woody caudices; leaves narrow, firm; phyllaries appressed, thin, ovate to lanceolate; receptacle naked, alveolate; ray flowers fertile; disk flowers perfect, the corollas somewhat enlarged upward and with 5-toothed margin; achene white-villous; pappus of white capillary bristles. (Greek, simple pappus.)

H. macleanii Brandegee.
Stenotus borealis Rydb.

Leaves mostly basal, linear, ciliate on the margins, about 1 cm. long and 1 mm. wide; heads on scapes 2–6 cm. long; ray and disk flowers yellow.

Known from several widely scattered localities in Yukon.

3. SOLIDAGO L.

Caulescent perennials; leaves alternate, entire or toothed; heads small, several-flowered, with small yellow rays; phyllaries well imbricated in several series; receptacle small, alveolate; pappus of capillary bristles; achenes usually ribbed. (Latin, to make whole.)

1A. Heads about 8 mm. high. .... 1. *S. multiradiata*
2A. Heads smaller.
 1B. Heads very numerous, the inflorescence usually more or less spreading. .... 2. *S. elongata*
 2B. Heads less numerous, in narrow, spike-like inflorescence.
  1C. Phyllaries lanceolate and acute at the summit... 3. *S. lepida*
  2C. Phyllaries linear-elliptic, rounded at the summit. 4. *S. decumbens*

1. *S. multiradiata* Ait. Northern Golden Rod.

Stems often several, glabrate below, pubescent above, up to 6 dm. tall but often very dwarf; leaves nearly glabrous but ciliate on the

margins, at least below, the lower spatulate or oblanceolate and narrowed into a margined petiole, the upper sessile; heads several and glomerate in a terminal cluster; phyllaries narrowly lanceolate and thin-edged; rays prominent and linear; achenes pubescent, about 3 mm. long. Var. *arctica* (DC.) Fern. has elongated upper leaves.

Common. Alaska—Labr.—Newf.—Colo.—B.C. Fig. 973.

2. *S. elongata* Nutt.

Stems leafy above, 3-8 dm. tall; leaves narrowly lanceolate, acuminate, up to 1 dm. long, somewhat serrate; heads 3-4 mm. long, very numerous, the branches of the inflorescence sometimes ascending but usually spreading; phyllaries linear-lanceolate, acute. By some authors considered to be a variety of *S. lepida*.

Central Alaska—Gt. Slave L.—Mont.—Nev.—Calif. Fig. 974.

3. *S. lepida* DC.

Stems 3–10 dm. tall, leafy; leaves oblong to lanceolate, coarsely and sharply serrate, up to 1 dm. long; inflorescence rather compact and spike-like, up to 1 dm. long, sometimes but little exceeding the leaves; heads 5–6 mm. long; phyllaries linear-lanceolate, attenuate-acute.

Unalaska along the coast to Calif. and Sask.—Que.—Mich.—Utah. Fig. 975.

4. *S. decumbens* Green var. *oreophila* (Rydb.) Fern.

Stems usually clustered, 2–6 dm. tall; leaves glabrous, spatulate or oblanceolate, crenate-serrate toward the apex, the stem leaves reduced and few; phyllaries linear or oblong; heads 4–6 mm. high; achenes hirsute.

Central Alaska—Mack.—Colo.—N. Mex.—B.C. Fig. 976.

4. ASTER (Tourn.) L.

Perennials with alternate leaves; heads 1 to many with purple, pink, or white rays, never yellow; phyllaries in several series, herbaceous or herbaceous-tipped; receptacle flat or convex, alveolate; disk flowers perfect, yellow changing to red brown or purplish; achenes mostly flattened and nerved; pappus of numerous slender capillary bristles. (Greek, a star.)

1A. Pappus white or lightly tinged brown.
  1B. Heads solitary. .... 1. *A. alpinus*
  2B. Heads usually more than one.
    1C. Leaves very narrow. .... 3. *A. junceus*
    2C. Leaves wider.
      1D. Lower leaves cordate or subcordate at the base. .... 7. *A. ciliolatus*
      2D. Lower leaves glaucous, narrowing into a winged petiole. .... 8. *A. laevis*

2A. Pappus medium to dark brown.
 1B. Stems 3 – 10 dm. tall.
  1C. Involucre and pedicels glandular. .... 6. *A. modestus*
  2C. Involucres not glandular. .... 4. *A. subspicatus*
 2B. Stems 8 – 40 cm. tall.
  1C. Leaves linear and entire. .... 2. *A. yukonensis*
  2C. Leaves wider and usually toothed. .... 5. *A. sibiricus*

1. *A. alpinus* L. Alpine Aster.

A. alpinus ssp. *vierhapperi* Onno.

Stems 1 to several from a thickish caudex, pilose, 15–30 cm. tall; leaves numerous, entire, pilose, those of the stem reduced; heads large, the involucre about 1 cm. high, 15–25 mm. broad; phyllaries of nearly equal length; rays violet, 1 cm. or more long.

Yukon—Mack.—Colo. and in Eurasia. Fig. 977.

2. *A. yukonensis* Cronq. Yukon Aster.

Stems somewhat pubescent, at least near the top, slender, 1 to several arising from a woody caudex, 1–2 dm. tall; leaves linear, acute, up to 6 cm. long and 3.5 mm. wide; heads usually one but occasionally 2, the involucre about 1 cm. high and about as broad; phyllaries pubescent, some of them mucronate; rays bluish violet, up to 1 cm. long.

Lake Kluane. Fig. 978.

3. *A. junceus* Ait. Rush-like Aster.

A. junciformis Rydb.

Stems 2–6 dm. tall, glabrate below, hirsute near the top; leaves linear-lanceolate or linear-oblanceolate, entire, 4–10 cm. long, 2–6 mm. wide; involucres about 7 mm. high by 1 cm. wide; inner phyllaries longer than the outer; rays with narrow ligules which are white to purple.

Southwest and central Alaska—Gt. Slave L.—N.S.—Penn.—Colo.—Wash. Fig. 979.

4. *A. subspicatus* Nees.

A. foliaceus Lindl.

Stems 3–9 dm. tall, smooth below, pubescent above; leaves entire or with a few short teeth, oblanceolate or the upper lanceolate or linear-lanceolate; involucres about 1 cm. high, 12–15 mm. broad; ray flowers purple, 12–20 mm. long; phyllaries green and nearly glabrous except on the margins.

Aleutians—along coast to Calif.—Ida.—Colo.—N. Mex. and in Labr. and Que. Fig. 980.

5. *A. sibiricus* L. Siberian Aster.

A. richardsonii Hook.

More or less pubescent throughout, 1–4 dm. tall; lower leaves

petioled, the upper sessile, 2–7 cm. long; heads 1–4 on each stem, the stems usually clustered; involucres about 12 mm. high and 15 mm. broad; phyllaries lanceolate, pubescent, the inner purplish; rays purple; pappus purplish brown.

All of Alaska—Mack.—Alta.—B.C. Fig. 981.

6. *A. modestus* Lindl. Great Northern Aster.

A. unalaskensis var. *major* Hook.

Stem stout, leafy, branched above, pubescent and glandular near the inflorescence, up to 15 dm. tall; leaves lanceolate, partly clasping, acuminate at the apex with a few sharp, distant teeth, up to 12 cm. long, pubescent; heads at the end of short branches; phyllaries linear-subulate, little imbricated; rays purple to violet, 1 cm. or more long.

Alaska Penin.—Ont.—Minn.—Ore. Fig. 982.

7. *A. ciliolatus* Lindl. Lindley Aster.

A. lindleyanus T. and G.

Stems glabrous or sparingly pubescent with crisp hairy lines above, 3–10 dm. tall; lower leaves cordate to obovate, serrate, up to 15 cm. long; upper leaves with winged petioles or sessile, the margins sometimes entire; involucres 7–8 mm. high, about 1 cm. broad; phyllaries linear-lanceolate with a green oblanceolate midrib; rays blue or violet, 10–12 mm. long; pappus nearly white.

Liard Hot Springs—Labr.—N. Hamp.—Ohio—Wyo.—B.C.

8. *A. laevis* L. Smooth Aster.

Stem upright, 3–12 dm. tall, glabrous and glaucous; leaves thick, entire or somewhat serrate, the basal ones tapering to winged petioles, the upper ones sessile and clasping; involucres 8–9 mm. high, about 1 cm. broad; rays blue or violet.

Near Yukon boundary—Maine—Ala.—La.—N. Mex.—B. C.

5. ERIGERON L.

Biennials or perennials; leaves alternate; heads 1 to many, radiate or discoid; phyllaries in 1 or 2 series, not much imbricated, usually narrow and not herbaceous; receptacle naked, flat, punctuate; rays usually narrow, in more than 1 series, pistillate; disk flowers yellow; pappus of a single series of rough capillary bristles, often with an outer whorl of short ones. Differs from *Aster* chiefly in the numerous narrow rays and in the involucre. (Greek, early old, in allusion to the pappus.)

1A. Rays inconspicuous or short.
  1B. Tubular-filiform pistillate flowers present between the hermaphrodite flowers and the outer ligulate flowers. ....14. *E. acris*
  2B. Tubular-filiform pistillate flowers absent. ....13. *E. lonchophyllus*
2A. Ray flowers more or less conspicuous.
  1B. Leaves deeply divided. ....11. *E. compositus*

2B. Leaves entire or nearly so.
  1C. Stems usually 1 dm. or less tall.
    1D. Plant densely caespitose. ....10. *E. purpuratus*
    2D. Stems usually only one.
      1E. Plant densely gnaphaloid-lanate. .... 7. *E. muirii*
      2E. Plant pubescent but not densely lanate.
        1F. Rays 1 mm. or more wide. .... 6. *E. hyperboreus*
        2F. Rays very narrow. .... 9. *E. humilis*
  2C. Stems usually more than 1 dm. tall.
    1D. Stems 5 – 30 cm. tall.
      1E. Rays 3 – 6 mm. long. .... 8. *E. uniflorus*
      2E. Rays longer.
        1F. Heads often more than 1. .... 3. *E. caespitosus*
        2F. Heads usually solitary.
          1G. Basal leaves narrow, elongate, acuminate or attenuate. .... 4. *E. yukonensis*
          2G. Basal leaves oblanceolate, tapering to the petiole. .... 5. *E. grandiflorus*
    2D. Stems usually 3 dm. or more tall.
      1E. Head usually solitary, large. .... 1. *E. peregrinus*
      2E. Heads usually several.
        1F. Rays more than 0.5 mm. wide. .... 2. *E. glabellus*
        2F. Rays less than 0.5 mm. wide. ....12. *E. philadelphicus*

1. *E. peregrinus* (Pursh) Greene.
Aster peregrinus Pursh.

Perennial, 2–5 dm. tall, densely villous on upper part, glabrate near the base; involucre about 15 mm. broad; rays purplish, 1 cm. or more long. Some collections from Douglas Island seem to be ssp. *callianthemus* (Greene) Cronq. which has glandular involucres. This species combines some characteristics of both *Aster* and *Erigeron*.

Common in the coast regions, Commander and Aleutian Islands—Colo.—Utah—Calif. Fig. 983.

2. *E. glabellus* Nutt. ssp. *pubescens* (Hook.) Cronq.

Hispid-bristly throughout, 3–6 dm. tall, often much branched from the base; heads on rather long peduncles; involucre about 8 mm. high and 15 mm. broad; rays long, white to pinkish-purple; when spread gives the head a diameter of 3–4 cm.

Central Alaska—Mack.—Wisc.—Colo.—Mont.—B.C. Fig. 984.

3. *E. caespitosus* Nutt.

Perennial with stout taproot and usually branched caudex; stems several, densely pubescent with short spreading hair, 5–35 cm. tall; leaves pubescent, the basal ones narrowly oblanceolate or spatulate, tapering to a petiole and up to 12 cm. long, the cauline smaller and sessile; heads solitary or few, 9–12 mm. wide; phyllaries appressed, thickened on the back; rays blue, white or pink, 5–15 mm. long.

Central Alaska and Yukon—Sask.—N. Dak.—Colo.—Ariz.—Wash. Fig. 985.

4. *E. yukonensis* Rydb.

Perennial with branched caudex; stems 6–40 cm. tall, villous-hirsute; leaves narrow, acuminate, hirsute-ciliate, at least along the margins, heads 1–4, mostly solitary, up to 17 mm. wide; involucre 7–10 mm. high, the phyllaries wooly-villous, narrow, with purplish tips; rays 45–75, pink to bluish purple, 10–15 mm. long; achenes 2-nerved, hairy.

Dawson—Lake Kluane—Whitehorse—Mack. Fig. 986.

5. *E. grandiflorus* Hook.

Stems decumbent at the base, 4–25 cm. tall; basal leaves oblanceolate, tapering to a petiole, hirsute-pilose, 1–9 cm. long, 4–8 mm. wide; stem leaves several, lanceolate to ovate; heads large, solitary; involucres 8–10 mm. high; phyllaries long villous or pilose, greenish below, reddish purple on the margins and the nearly naked tips; achene copiously hirsute.

Central Alaska—Alta.—B. C. Fig. 987.

6. *E. hyperboreus* Greene.

E. alaskanus Cronq.

Stems 5–10 cm. tall, spreading-hirsute; basal leaves oblanceolate, tapering to a short petiole or subsessile, 1–5 cm. long; stem leaves linear, few and reduced; heads solitary, 9–15 mm. wide; involucre 5–8 mm. high, somewhat viscid or glandular; phyllaries slender, attenuate, green to purplish black; rays 40–60, 2-toothed at the apex, 9–12 mm. long, 1–2 mm. wide, blue; achenes villous-hirsute.

Seward Penin.—Kivelina—Porcupine River. Fig. 988.

7. *E. muirii* Gray.

Perennial with stout caudex, the whole plant densely gnaphaloid-lanate; basal leaves oblanceolate or spatulate, 15–30 mm. long, 5–7 mm. wide; stem leaves several; involucre 8–9 mm. high; phyllaries purple under the dense tomentum; rays 75–100, 10–13 mm. long; achenese villous-hirsute.

Cape Thompson and Anaktuvuk Pass region.

8. *E. uniflorus* L. ssp. *eriocephalus* (J. Vahl) Cronq.

E. eriocephalus J. Vahl.

Stems 3–35 cm. tall, sparingly to densely villous with crinkled hairs; leaves villous when young, approaching glabrate with age, the basal oblanceolate, up to 9 cm. long and 8 mm. wide; stem leaves few; heads usually solitary, the disk 15–30 mm. wide; involucre usually densely wooly-villous; phyllaries tinted deep purple; rays 100 or more, white to pink or purple, 3–6 mm. long.

Arctic Alaska—Greenl.—Que.—Central Alaska. Fig. 989.

9. *E. humilis* Grah.

E. unalaskensis (DC.) Ledeb.

Stems 2–20 cm. tall, villous throughout; basal leaves oblanceolate, up to 8 cm. long and 11 mm. wide; heads solitary; involucre 6–9 mm. high; phyllaries black-purple, rays 50–150, 3–6 mm. long, erect or ascending.

Circumpolar, south to Que. and Mont. Fig. 990.

10. *E. purpuratus* Greene.

Caespitose; stems 1–10 cm. tall, leafy at the base, more or less villous; leaves oblanceolate or spatulate, up to 3 cm. long and 5 mm. wide; heads solitary, the disk 10–15 mm. wide; involucre 7–10 mm. high, villous; rays 60–90, white or pink, 4–8 mm. long.

Central Alaska—Yukon—B.C. Fig. 991.

11. *E. compositus* Pursh.

Hispid-hirsute throughout; leaves mostly basal, 1–4 times ternately lobed or dissected; stem leaves few and reduced; stems scapiform, up to 25 cm. tall; heads solitary, the disk 8–20 mm. wide; rays 20–60, white, pink or blue, up to 12 mm. long but usually shorter and often inconspicuous. The typical form has leaves 2–4 times ternate with long linear divisions. Var. *glabratus* Macoun has 2–3 times ternate leaves with shorter divisions. Var. *discoideus* Gray has leaves simply ternate.

Central Alaska—Greenl.—Que.—S. Dak.—Ariz.—Calif. Fig. 992.

12. *E. philadelphicus* L.

Biennial or short-lived perennial, more or less pubescent with long spreading hairs, 2–8 dm. tall, branched above; basal leaves oblanceolate to obovate, tapering into a short petiole, up to 15 cm. long and 3 cm. wide; stem leaves clasping, ample; heads few to many in an open inflorescence; phyllaries green with hyaline margins; rays more than 100, very narrow, pink or rose-purple.

Liard Hot Springs—Mack.—Labr.—Maine—Texas—Calif.

13. *E. lonchophyllus* Hook.

Biennial or short-lived perennial; stems 1 to many, 1–3 dm. tall, nearly glabrate at the base but increasingly bristly-hairy toward the top, the same type of hairs on the lower edge of the upper leaves and on the phyllaries; lower leaves narrowly oblanceolate, up to 15 cm. long; heads few or several, the involucre 4–9 mm. high; rays numerous, white or pinkish, 2–3 mm. long.

Central Alaska—Yukon—Sask.—N. Dak.—N. Mex.—Calif. and in Ont. and Que. Fig. 993.

14. *E. acris* L.

Biennial or perennial; stems 1–8 dm. tall, subglabrous to spreading-hirsute; leaves subglabrous to hirsute, the basal one oblanceolate, entire or remotely serrulate, up to 10 cm. long and 15 mm. wide; heads one to many; involucres 5–12 mm. high; rays white to pink or purplish, 2.5–4.5 mm. long. This is our commonest *Erigeron* and occurs in 3 varieties. Var. *asteroides* (Andriz.) DC. 3–8 dm. tall, erect, heads several to many; peduncles and involucre glandular, rays pinkish. Var. *debilis* Gray plant 2–25 cm. tall; heads solitary or few, peduncles and involucre glandular; rays pinkish. Var. *elatus* (Hook.) Cronq. plant 1–4 dm. tall, erect; heads solitary or few; peduncles and involucre more or less hirsute, not glandular; rays white or pinkish, short.

Circumpolar, south to Maine, Mich., Colo., Calif. Fig. 994.

6. ANTENNARIA Gaertn.

Wooly, dioecious perennials; leaves basal and alternate; heads small, discoid, many-flowered; inflorescence dry, scarious, white, brown or rose; pistillate corollas with filiform corollas, the staminate flowers with tubular, 5-lobed corollas and rudimentary styles and ovaries; pappus of capillary bristles. There is much apomixis in this group which makes it very difficult to determine true species. Many of the forms here described should perhaps be regarded as subspecies or varieties. The treatment here largely follows the treatment of the genus by Dr. A. E. Porsild of the National Museum of Canada. (White pappus of sterile flowers suggests the antenna of certain insects.)

1A. Basal leaves prominently 3-nerved, 4 – 16 cm. long. .. 1. *A. pulcherrima*
2A. Basal leaves single-nerved, lateral nerves if any obscure.
  1B. Tall, rather broad-leaved plants with large heads. 2. *A. howellii*
  2B. Tall, medium or dwarf species with small heads.
    1C. Bracts of the involucre (phyllaries) with pale greenish-brown to olivaceous or dark brown with usually acuminate and erose tips.
      1D. Plant normally monocephalous.
        1E. Plants with stolons. .... 3. *A. philonipha*
        2E. Plants densely tufted, lacking stolons.
          1F. Male and female usually present. .... 4. *A. monocephala*
          2F. Only the female plants known.
            1G. Inner phyllaries normally with blunt, pale, straw-colored tips. ....24. *A. pygmaea*
            2G. Inner phyllaries with attenuate, olive-brown tips. .... 5. *A. angustata*
      2D. Plant normally with more than one head.
        1E. Male and female plants usually present.
          1F. Involucre 4 – 5 mm. high. .... 6. *A. alaskana*
          2F. Involucre about 6 mm. high.
            1G. Basal leaves spatulate, 10 – 15 mm. long. 7. *A. neoalaskana*
            2G. Basal leaves about 6 mm. long. .... 8. *A. densifolia*
        2E. Only the female plant known.
          1F. Plant caespitose with numerous sessile sterile rosettes.
            1G. Basal leaves narrowly oblanceolate, tapering to the apex, pappus rufidu-

lous .... 9. *A. ekmaniana*
2G. Basal leaves spatulate-obovate, rounded at the apex; pappus white.
1H. Plant pulvinate, basal leaves short, obovate. .... 10. *A. compacta*
2H. Plant caespitose but not pulvinate; leaves longer. .... 11. *A. subcanescens*
2F. Plants loosely caespitose with basal rosettes borne on well-developed prostrate or ascending stolons.
1G. Achenes papillose.
1H. Inflorescence rather compact; inner phyllaries dark brown. .... 12. *A. stolonifera*
2H. Inflorescence open; inner phyllaries pale brown. .... 13. *A. pedunculata*
2G. Achenes glabrous.
1H. Heads 1 – 3, 7 – 9 mm. high. .... 14. *A. megacephala*
2H. Heads 3 – 5, 6 – 7 mm. high. .... 15. *A. pallida*
2C. At least the inner phyllaries with papery, white, straw-colored or pink and usually ligulate non-attenuate tips.
1D. Inner phyllaries pink.
1E. Male plant as common as the female. .... 16. *A. dioica*
2E. Only female plants known in our region.
1F. Fruiting stems usually 20 cm. or more tall.
1G. Plants with well developed stolons.
1H. Basal leaves glabrate above; cauline leaves ample. .... 17. *A. alborosea*
2H. Basal leaves not glabrate above, stem leaves reduced.
1J. Basal leaves narrowly spatulate; phyllaries pale pink, soon becoming pale gray or straw-colored. .... 18. *A. elegans*
2J. Basal leaves oblanceolate; phyllaries pink even in age. .... 19. *A. rosea*
2G. Plant with short, sessile offsets; leaves spatulate-obovate. .... 20. *A. oxyphylla*
2F. Fruiting stems less than 20 cm. tall.
1G. Heads nodding in youth; plants with matted growth. .... 21. *A. breitungii*
2G. Heads not nodding in youth; basal leaves erect. .... 22. *A. incarnata*
2D. Inner phyllaries papery white or straw-colored; never pink.
1E. Monocephalous or rarely with 2 or 3 heads.
1F. Basal leaves 1 – 3 cm. long. .... 23. *A. shumaginensis*
2F. Basal leaves rarely over 1 cm. long. ...... 24. *A. pygmaea*
2E. Heads normally more than 1.
1F. Tall plants, usually 20 cm. or more tall. ... 27. *A. leuchippi*
2F. Dwarf to medium plants.
1G. Heads nodding when young; inflorescence glomerate; phyllaries papery white.
1H. Cauline leaves without scarious tips. .. 25. *A. laingii*
2H. Upper 1 – 3 cauline leaves with slender scarious tips. .... 26. *A. nitida*
2G. Heads not nodding in youth; inflorescence open; phyllaries thin and soft.
1H. Upper 1 – 3 cauline leaves with slender scarious tips. .... 23. *A shumaginensis*
2H. Upper 5 – 8 cauline leaves with broad, flat and very prominent scarious appendages. .... 29. *A. isolepis*

1. *A. pulcherrima* (Hook.) Greene.

Stems 2–5 dm. tall; basal leaves 4–12 cm. long; stem leaves narrow and much reduced; heads 4–20, the pistillate with involucres 7–8 mm. high; phyllaries in 3 series, lanate at the base, the tips scarious and pale brown; pappus white; achenes glabrous. Var. *angutisquama* Porsild of the Pelly Range has phyllaries long-attenuate and glabrate attenuate leaves.

Central Alaska—Gt. Bear L.—Newf.—Colo.—Wash. Fig. 995.

2. *A. howellii* Greene.

Young stolons flagellate, up to 1 dm. long; rosette leaves 25–50 mm. long, 5–20 mm. wide, glabrous above; mature stems 20–35 cm. tall, greenish purple with thin lanate tomentum; heads 4–8, the lateral ones on peduncles up to 1 cm. long; involucres about 1 cm. high; phyllaries linear-lanceolate, greenish brown and lanate below, with long-attenuate, tawny and papery tips.

Southeast Yukon—Sask.—Mont.—Ore. Fig. 996.

3. *A. philonipha* Porsild.

Plant matted with offsets 5–10 cm. long; basal leaves spatulate-obovate, grabrous above, about 15 mm. long and 4 mm. wide; stems slender and weak, the pistillate plant 8–14 cm. tall, the staminate shorter; pistillate involucres 6–7 mm. high; phyllaries of equal length, thin, hyaline, acuminate; pappus rufidulous; style exerted; achenes glabrous.

Seward Penin.—Artic Coast—Mack.—B. C. Fig. 997.

4. *A. monocephala* DC.

Often forming small mats with the offsets only a few cm. long; basal leaves spatulate-obcuneate, about 1 cm. long, mucronate, glabrous above; stems 2–10 cm. tall, rarely taller, the stem leaves with prominent scarious tips; pistillate involucres 4–5 mm. high; phyllaries dark brown to almost black in the middle; style long-exerted. Var. *exilis* (Greene) Hult. has silvery-appressed upper leaf surfaces and up to 5 cm. long runners.

East Asia—Mackenzie Mts.—B.C.—Aleutians. Fig. 998.

5. *A. angustata* Greene.

Caespitose with sessile or subsessile offsets; basal leaves narrowly oblanceolate, 8–13 mm. long, about 2 mm. wide; stems 5–14 cm. tall bearing 7–11 linear leaves with flat scarious tips; involucres 8–10 mm. high, thinly lanate at the base; phyllaries long-attenuate, olivaceous; style included or short-exerted; pappus white; achene glabrous.

Wainwright, Mack.—Greenl.—Canadian Rockies. Fig. 999.

6. *A. alaskana* Malte.

Caespitose with branched caudex; basal leaves narrowly spatulate-oblanceolate, 1–3 cm. long, 2–4 mm. wide, cinereous-tomentose on both surfaces; cauline leaves linear with short scarious tips; stems 3–17 cm. tall; heads 3–5; phyllaries densely imbricated and with olivaceous tips; pappus tawny.

Bering Sea region—central Alaska. Fig. 1000.

7. *A. neoalaskana* Porsild.

Caespitose, the offsets sessile; basal leaves spatulate, 10–15 mm. long, 2–3 mm. wide, appressed-tomentose on both surfaces, glabrate in age; stems 5–12 cm. tall, stiff, with 4–7 scarious-tipped leaves; heads mostly three; pappus white; tips of corolla pale yellow; style much exerted; achenes minutely papillose.

Known from Richardson Mts. and Sadlerochit River.

8. *A. densifolia* Porsild.

Densely caespitose, the offsets short and crowded; basal leaves densely congested, cuneate-obovate or broadly oblanceolate, obtuse and not mucronate, 5–6 mm. long, 3 mm. broad, densely and yellowishly tomentose on both surfaces; stems 6–9 cm. tall; cauline leaves 5–7 with subulate tips; heads 2–4 on 5 mm. long peduncles; corolla lobes purplish; style exerted, bifid; pappus white; achenes glabrous.

Mackenzie Mts.

9. *A. ekmaniana* Porsild.

Densely caespitose; basal leaves linear-oblanceolate, densely appressed-tomentose on both surfaces, 10–22 mm. long, 2–3 mm. wide; stems 1–2 dm. tall, purplish-tinged; heads 1–7; involucres about 7 mm. high; outer phyllaries lanceolate, the inner long-attenuate, light chestnut brown; pappus subrufescent; style exerted; achenes glabrous or minutely papillose.

East Asia—Alaska—Yukon—Greenl.—Labr. Fig. 1001.

10. *A. compacta* Malte.

Densely caespitose; basal leaves broadly oblanceolate-obovate, 4–8 mm. long, 2.5–4 mm. wide, densely appressed canescent-tomentose on both surfaces; stems 5–10 cm. tall, often arched; cauline leaves 5–9 with long scarious appendages; heads (1) 2–4; involucres 6–7 mm. high; phyllaries oblong, dusky brown, in age tawny, the inner narrower, olivaceous, with attenuate, erose tips; style barely exerted; pappus white; achenes glabrous.

Seward Penin.—Victoria Isl.—Yukon—Mack. Fig. 1002.

11. *A. subcanescens* Ostf.

Caespitose, forming dense cushions; basal leaves oblanceolate, 15–25 mm. long including petiole, 4–5 mm. wide, thinly appressed-tomentose on both surfaces; stems 5–10 cm. tall, dark purplish, glandular-papillose under the indument; cauline leaves 5–7, with long scarious appendages; heads usually 3; involucre about 7 mm. high; phyllaries dark brown with greenish-brown tips; style exerted; pappus dirty white.
Cape Lisburne—Coronation Gulf—south Yukon—Alaska Range.

12. *A. stolonifera* Porsild.

Stolons leafy, freely rooting, 5–10 cm. long; basal leaves sericeous-tomentose, spatulate, obtuse, mucronate, 15–25 mm. long, 3–5 mm. wide; stems elongating in fruit to 14–18 cm. tall; uppermost stem leaves with scarious tips; heads 3–5; phyllaries dark; styles scarcely exerted; achenes small, papillose.
Southeast Yukon. Fig. 1003.

13. *A. pedunculata* Porsild.

Stolons procumbent, 5–10 cm. long; basal leaves oblanceolate, mucronate, 2 cm. long, 5 mm. wide, sericeous, becoming glabrescent in age; stems 15–22 cm. tall; heads 1–5, the lower with peduncles 3–6 cm. long; involucres 7–10 mm. high; corolla purple; styles strongly exerted, bifid; achenes strongly papillose, 1 mm. long.
Pelly Range and Umiat.

14. *A. megacephala* Fern.

Stolons densely leafy, short and suberect; basal leaves spatulate-obovate or broadly oblanceolate, mucronate, 8–12 mm. long, 3–4 mm. wide, the upper surface glabrescent in age; stems 5–12 cm. tall; cauline leaves 5–9, linear with prominent scarious tips; heads 1–3; involucres 8–10 mm. high; phyllaries dark green or olivaceous; style barely exerted, bifid; pappus white; achenes glabrous.
Southeast Yukon and north B. C.

15. *A. pallida* E. Nels.

Stolons well developed; basal leaves spatulate-oblanceolate, 10–15 mm. long, appressed wooly on both surfaces; stems 6–15 cm. tall; cauline leaves 7–9, almost lacking scarious appendages; heads 3–6; involucres 6–7 mm. high; inner phyllaries with dirty white erose tips; pappus white; achenes glabrous.
Aleutians—Alaska Range—southeast Alaska. Fig. 1004.

16. *A. dioica* (L.) Gaertn.

Offsets short and ascending; basal leaves obovate, mucronate, glabrous above, 1–2 cm. long, 3–6 mm. wide; heads 3–6; involucre 7–9

mm. high; inner phyllaries scarious, white or tinted rose; corollas rose-purple; styles exerted, bifid; stems 10–15 cm. tall; cauline leaves 7–10, the uppermost with slightly scarious margin.

A Eurasiatic species occurring in the west Aleutians. Fig. 1005.

17. *A. alborosea* Porsild.

Stolons creeping, branching, 5–10 cm. long; basal leaves oblanceolate-cuneate, mucronate, glabrous above 15–30 mm. long, 4–6 mm. wide; stems 20–35 cm. tall; stem leaves 14–20, linear-lanceolate, glabrate; heads 5–10; involucres 6–7 mm. high; inner phyllaries roseate, later straw-colored; style scarcely exerted; pappus white.

Central Alaska—Gt. Bear L.—Alta.—B.C. Fig. 1006.

18. *A. elegans* Porsild.

Humifuse; basal leaves spreading, linear-oblanceolate, acute, 8–20 mm. long, 2–3 mm. wide, appressed-sericeous on both surfaces; stems 12–20 cm. tall; upper stem leaves with scarious tips; heads 1–8. on elongated peduncles; involucres 5–6 mm. high; inner phyllaries oblong-lanceolate, acuminate, erose, pale rose when young, becoming gray or straw-colored.

Southeast Yukon and Gt. Bear Lake. Fig. 1007.

19. *A. rosea* (Eaton) Greene.

Stolons long, ligneous, branching; basal leaves oblanceolate, 10–25 mm. long, 2–4 mm. wide with densely appressed pale tomentum; stems 12–20 cm. tall; stem leaves 8–10, without scarious tips; heads 4–10; involucres 4–5 mm. high; inner phyllaries dark rose or pink, fading in age; pappus dirty white; style not exerted; achenes glabrous.

Pacific coast of Alaska—central Yukon—S. Dak.—Alta. Fig. 1008.

20. *A. oxyphylla* Greene.

Stolons short, leafy, ascending; basal leaves 10–20 mm. long, 4–7 mm. wide, obovate-oblanceolate, mucronate, silvery-gray on both surfaces; stems 16–30 cm. tall, slender; stem leaves 9–12, the upper with scarious tips; heads 3–10; involucres 6–7 mm. high; inner phyllaries pale pink turning straw-color; pappus white; corollas reddish-purple; style barely exerted; achenes glabrous.

Central Alaska—Yukon—Lake Athabaska. Fig. 1009.

21. *A. breitungii* Porsild.

Humifuse; stolons up to 8 cm. long; basal leaves narrowly spatulate-obovate, 5–7 mm. long, 2–3 mm. wide, cinereous-tomentose on upper surface but becoming glabrate in age; stems 8–15 cm. tall; stem leaves 8–10, linear-oblong with scarious tips; heads 4–8; involucre 5–6 mm. high; phyllaries rose pink; achenes papillose.

Alaska and south Yukon.

22. *A. incarnata* Porsild.

Stolons suberect, 3–5 cm. long; basal leaves oblanceolate or spatulate, acute, 1 cm. long, 2–3 mm. wide; stems 8–12 cm. tall; stem leaves 7 or 8, with acute or attenuate scarious tips; heads 4–10; involucres about 5 mm. high; inner phyllaries pale rose.

Pelly Range. Fig. 1010.

23. *A. shumaginensis* Porsild.

Stolons short and erect; basal leaves 1–3 cm. long, 3–6 mm. wide, spatulate-obovate, mucronate, glabrate above; stems 8–15 cm. tall, with 5–8 leaves; heads 1–3; involucres 6–7 mm. high; inner phyllaries pale; corolla purplish; style exerted.

Shumagin Isls., Naknek and Robertson River.

24. *A. pygmaea* Fern.

Stolons short, erect-ascending, forming tufts; basal leaves oblanceolate, mucronate, 8–14 mm. long, 3–4 mm. wide, glabrate above; stems 4–14 cm. tall, bearing about 9 glabrate leaves; heads solitary or occasionally 1 or 2 smaller heads below the terminal one; involucre about 7 mm. high; inner phyllaries with stramineous tips; pappus silky, white; style barely exerted.

Pelly Range—Labr.

25. *A. laingii* Porsild.

Offsets stolon-like; basal leaves 10–15 mm. long, about 3 mm. wide, oblanceolate-spatulate, acuminate, densely canescent-tomentose on both surfaces; stems 8–14 cm. tall with leaves not scarious-tipped; heads 3–8; involucres 5–6 mm. high; inner phyllaries ivory white, obtuse; pappus white; achenes glabrous.

Central Alaska—south Yukon—Rocky Mts. Fig. 1011.

26. *A. nitida* Greene.

Densely matted with freely branching stolons; basal leaves obovate-oblanceolate, silvery white on both surfaces, 5–15 mm. long, 3–5 mm. wide; stems 5–25 cm. tall bearing 8–20 linear leaves, the uppermost with attenuate scarious tips; inflorescence glomerate when young, open and branched in age; involucres 6–7 mm. high; phyllaries with papery white tips; styles barely exerted.

Central Alaska—Gt. Bear L.—James Bay—Sask.—B. C. and in Rocky Mts. to N. Mex. Fig. 1012.

27. *A. leuchippi* M. P. Porsild.

Leafy stolons up to 9 cm. long; basal leaves 20–25 mm. long, about 4 mm. wide, oblanceolate-spatulate, mucronate, white-tomentose on both surfaces; stems greenish-purple, 20–30 cm. tall with about 15 evenly spaced leaves; heads 6–10; involucres 5–6 mm. high; phyllaries

mostly with white tips, in youth dotted with pink spots; corolla purple; style not exerted.

South Alaska and Yukon. Fig. 1013.

28. *A. subviscosa* Fern.

Humifuse; basal leaves oblanceolate-spatulate, obtuse, 8–15 mm. long, 2–5 mm. wide, densely white-tomentose on both surfaces; stems 8–14 cm. tall with about 10 leaves; heads 3–6; involucres 5–6 mm. high; inner phyllaries nearly white; pappus white; style barely exerted; achenes glabrous.

Southeast Yukon, Lake Athabasca, and Gaspe, Que. Fig. 1014.

29. *A. isolepis* Greene.

Humifuse with leafy stolons up to 5 cm. long; basal leaves oblanceolate, 1–2 cm. long, 2–5 mm. wide, appressed white-tomentose on both surfaces; stems 10–15 cm. tall, the upper cauline leaves with broad, flat, scarious tips; heads 3–6, rarely more; involucres 6–7 mm. high; phyllaries with erose papery white tips; pappus white.

Central Alaska—Gt. Bear L.—Labr.—Que.—B. C. Fig. 1015.

7. ANAPHALIS DC.

White-tomentose or wooly perennials; leaves alternate, entire; heads discoid, with polygamo-dioecious flowers; involucres hemispheric, the imbricated phyllaries in several series and pearly white; pistillate flowers with filiform corollas, the perfect but sterile central flowers with 5-toothed tubular corollas; pappus of capillary bristles. (Greek, name of some similar plant.)

A. margaritacea (L.) Benth. & Hook. Pearly Everlasting.

Stems 2–6 dm. tall; leaves 5–10 cm. long, 3–15 mm. wide, densely white-tomentose below, less so above, the upper surface glabrate in age; heads numerous, in a compound corymb, 6–7 mm. high, about 8 mm. broad; phyllaries pearly white. A very variable group some forms of which have been described as species.

East Asia—Aleutians—Labr.—Penn.—Kans. Fig. 1016.

8. GNAPHALIUM L.

Annual, biennial, or perennial herbs; leaves alternate, entire, narrow, wooly; heads discoid, of outer pistillate flowers with filiform corollas and a few perfect flowers with tubular corollas; phyllaries dry, scarious; pappus a row of capillary bristles. (Greek, referring to the wool.)

G. uliginosum L.

A wooly annual, 4–20 cm. tall, often diffusely branched; heads very small, in dense, terminal, leafy-bracted clusters; phyllaries linear, acute, brownish; achenes about two thirds of a mm. long.

Introduced as a weed in several places, native of Eurasia. Fig. 1017.

9. MADIA Molina.

Glandular-viscid, heavy-scented annuals; leaves entire, narrow and at least some of them alternate; heads radiate, 1- to many-flowered; rays yellow, small and inconspicuous; phyllaries in a single series, strongly inflexed, and each inclosing an achene; achenes angled, those of the ray flowers flattened and very oblique; pappus none. (Madi, the Chilian name.)

M. glomerata Hook. Tarweed.

Plant 3–8 dm. tall, leafy, hirsute throughout, glandular in the inflorescence; leaves linear; heads glomerate, about 6 x 4 mm.; achenes from the ray flowers somewhat curved, those from the disk flowers 4- to 5-angled.

Matanuska—Yukon—Sask.—Colo.—Calif. Probably introduced in our area. Fig. 1018.

10. HELIANTHUS L.

Coarse annuals or perennials; leaves large, simple; heads large, 1 to many; rays yellow, neutral, spreading; phyllaries in several series; receptacle chaffy, the chaff subtending the disk flowers; achenes 4-angled or flattened. (Greek, sun and flower.)

H. annuus L. Common Sunflower.

Stem hispid or scabrous, 3–25 dm. tall, usually branched; leaves broadly ovate, 3-ribbed, coarsely dentate; phyllaries usually long-acuminate. In cultivation the heads are often very large.

Adventitive at Fairbanks and Manly Hot Springs. Native of the central and southwestern states.

11. BIDENS L.

Herbs; leaves opposite, serrate, lobed or dissected; heads rather large, mostly with rays; phyllaries in 2 series, the outer often foliaceous; receptacle chaffy, the chaff subtending the disk flowers; achenes flat or quadangular, cuneate to linear; pappus of two or four teeth or subulate barbed awns. (Latin, 2-toothed, from the achene.)

B. cernua L. Nodding Bur-Marigold.

Annual; 2–7 dm. tall; leaves sessile, lanceolate, distantly serrate, sometimes connate at the base; heads several to many, 15–25 mm. broad; achenes 4-angled with 4 awns, 5–6 mm. long.

Galena and Manly Hot Springs. Probably introduced. Fig. 1019.

12. ACHILLEA (Vail.) L.

Erect perennial leafy plants; leaves alternate, varying from serrate

to tripinnatifid; heads corymbose, small, with white or rose-colored rays; phyllaries scarious-margined, in several unequal imbricated series; achenes oblong or obovate, flattened, margined; pappus none. (Named for Achilles of mythology.)

1A. Leaves pinnatifid. .... 1. *A. sibirica*
2A. Leaves bi- or tripinnate.
  1B. Involucres 5 – 7 mm. high. .... 2. *A. borealis*
  2B. Involucres 4 – 4.5 mm. high.
    1C. Ultimate leaf segments linear; rachis merely margined. .... 3. *A. lanulosa*
    2C. Ultimate leaf segments lanceolate; rachis winged. 4. *A. millefolium*

1. *A. sibirica* Ledeb. Siberian Yarrow.

A. multiflora Hook.

Stems 3–12 dm. tall, villous; heads numerous, 4–5 mm. high and 4–6 mm. broad; phyllaries villous, elliptic with brown margins; ray flowers with much smaller ligules than in the following species.

Asia—Bethel—Gt. Bear L.—Man.—B. C. and Gaspe Penin. Fig 1020.

2. *A. borealis* Bong. Northern Yarrow.

Stems 2–5 dm. tall, more or less silky-villous; leaves 5–15 cm. long; heads larger than in the two following species; phyllaries lanceolate with prominent dark margins; ligules of the ray flowers white or pinkish.

Common and widespread; Alaska—Newf.—Que.—N. Mex.—Calif. Fig. 1021.

3. *A. lanulosa* Nutt.

Copiously villous with long silky hairs, 2–6 dm. tall; leaves 5–10 cm. long, villous; phyllaries elliptic, obtuse, with greenish midrib and straw-colored or brownish margins; achenes margined.

Alaska and Yukon—Sask.—Minn.—Kans.—Calif. Fig. 1022.

4. *A. millefolium* L.

Stems erect, 3–10 dm. tall, more or less villous; leaves 5–10 cm. long, finely villous to glabrate; primary segments spreading and more or less decurrent on the wing-margined rachis; achene scarcely margined.

Klondyke Valley; native of Eurasia and common in the states. *A. ptarmica* L. sometimes persists from cultivation. The leaves are simply serrate and the ligules are 4–5 mm. long.

13. ANTHEMIS L.

Herbs with pinnatifid or dissected leaves; heads peduncled, rather large, radiate; involucre saucer-shaped or hemispheric; phyllaries scarious, in several series; receptacle conic or hemispheric, chaffy; pappus none or a small crown; achenes glabrous, terete or ribbed. (Ancient name of the Chamomile.)

A. cotula L. Mayweed, Dog-Fennel.

Maruta cotula (L.) DC.

An ill-scented annual; rays white, disk flowers yellow; involucre 8–12 mm. broad; phyllaries oblong, obtuse, pubescent; achenes 10-ribbed.

An introduced weed and not common.

A. tinctoria L. a yellow-flowered perennial sometimes persists after cultivation.

14. CHRYSANTHEMUM L.

Annual or perennial herbs; leaves alternate, usually dentate, incised or dissected; heads large, peduncled, usually radiate; phyllaries in 2 or 3 series, scarious-margined; receptacle flat or convex, naked; achenes angled or terete, 5- to 10-ribbed, those from the ray flowers commonly 3-angled; pappus none. (Greek, golden flower.)

1A. Leaves small, narrow, entire. .... 1. *C. integrifolium*
2A. Leaves larger, toothed or lobed.
1B. Stem leaves cuneate-spatulate, toothed or lobed above. .... 2. *C. arcticum*
2B. Stem leaves linear-spatulate, pinnately incised. ... 3. *C. leucanthemum*

1. *C. integrifolium* Rich.

Perennial; stems 2–18 cm. tall, pubescent, scape-like with 1–4 leaves; leaves mostly basal, linear, 1–4 cm. long; heads solitary, the disk 8–15 mm. broad; involucre 5–8 mm. high; phyllaries rounded at the apex, green with wide brownish-black scarious margins; rays white, 5–10 mm. long.

Bering Sea—Arctic—central Alaska—north B. C. and in Asia. Fig. 1023.

2. *C. arcticum* L. Arctic Daisy.

Stems usually simple, 1–6 dm. tall; leaves somewhat fleshy; heads solitary, the disk 15–25 mm. broad; rays white, 10–25 mm. long; phyllaries oblong, obtuse, with broad purplish-brown margins. A low form of the northern Bering Sea and Artic Coast with glabrous basal parts and cuneate, not pinnatifid leaves has been described as ssp. *polaris* Hult.

Circumpolar, south to south Hudson Bay and southeast Alaska. Fig. 1024.

3. *C. leucanthemum* L. Ox-Eye Daisy.

Stems 3–9 dm. tall, simple or forking; basal leaves obovate or spatulate, dentate; upper leaves more or less incised; heads on long peduncles; involucres 12–15 mm. broad; phyllaries oblong-lanceolate, obtuse, with narrow band of purplish-brown and scarious margins; rays white, 12–15 mm. long.

Sparingly introduced; native of Eurasia.

15. MATRICARIA L.

Leaves alternate, 1- to 3-pinnatifid into narrow divisions; involucre saucer-shaped to hemispheric; phyllaries in 2-4 series, somewhat imbricate, obtuse, with scarious margins; receptacle conic or hemispheric, naked; achenes 3- to 5-ribbed. (Latin, mother and dear, from medicinal virtues of some species.)

1A. Annual; heads discoid. .... 1. *M. suaveolens*
2A. Heads radiate.
  1B. Plant 1–3 dm. tall. .... 2. *M. ambigua*
  2B. Plant 3–6 dm. tall. .... 3. *M. inodora*

1. *M. suaveolens* (Pursh) Buch. Pineapple Weed.

Chamomilla suaveolens (Pursh) Rydb.

Glabrous, leafy, much branched weed, 1–4 dm. tall; heads 8–10 mm. in diameter; phyllaries with broad, scarious margins; pappus an obscure crown. The odor is very distinctive.

Circumpolar as a native or introduced plant south to Mass. and Mo. Fig. 1025.

2. *M. ambigua* (Ledeb.) Kryl. Arctic Chamomile.

M. grandiflora (Hook.) Britt.

Perennial; stems glabrous, branched above or simple and monocephalus; leaves 1- to 2-pinnately dissected, 2–7 cm. long; disks 12–20 mm. wide; phyllaries obtuse, glabrous, brown or with wide, dark brown, scarious margins; rays white, 15–25 mm. long.

Seward Penin.—Arctic—Hudson Bay—Baffin Land—Greenl. and in Eurasia. Fig. 1026.

3. *M. inodora* L. Scentless Chamomile.

Annual or biennial; stems usually much branched and glabrous or nearly so; leaves 2- to 3-pinnately dissected into filiform lobes, up to 15 cm. long; phyllaries with brown scarious margins; rays white. Cultivated forms are usually double.

Adventitive at Fairbanks. Native of Europe.

16. ARTEMISIA (Tourn.) L.

Odorous perennial herbs or shrubs with alternate leaves; heads usually small, discoid, many-flowered, usually nodding when young, with greenish or yellowish flowers; involucres campanulate or hemispheric; phyllaries in 2–4 series; achenes ellipsoid; pappus none. (Named for Artemisia, wife of Mausolus.)

1A. All leaves entire or the lower 3-toothed or lobed at the apex.
  1B. Plant glabrous. .... 1. *A. dracunculus*
  2B. Plants white-tomentose. ....15. *A. gnaphalodes*
2A. Lower leaves deeply lobed to pinnate.
  1B. Low caespitose pulvinate species
    1C. Corolla pilose. .... 5. *A. glomerata*

2C. Corolla glabrous.
1D. Leaves completely covered with long white hairs. .... 6. *A. senjavinensis*
2D. Leaves sparingly silky, green above. .... 7. *A. globularia*
2B. Plants not pulvinate-caespitose.
1C. Receptacle hairy. .... 4. *A. frigida*
2C. Receptacle glabrous.
1D. Stem leaves large, often more than 5 cm. long, usually not divided to the midrib.
1E. Flowers reddish. ....16. *A. unalaskensis*
2E. Flowers yellowish-brown. ....17. *A. tilesii*
2D. Stem leaves divided usually to the midrib.
1E. Phyllaries white-tomentose on the back.
1F. Ultimate divisions of the leaves oblanceolate or spatulate. ....14. *A. kruhsiana*
2F. Ultimate divisions of the leaves linear.
1G. Phyllaries with blackish-brown scarious margins. ....12. *A. trifurcata*
2G. Phyllaries with light-colored scarious margins. .... 13. *A. alaskana*
2E. Phyllaries lacking tomentum on the back.
1F. Stem leaves 2-to 3-pinnatifid.
1G. Leaf segments ascending, all acute. ..... 8. *A. arctica*
2G. Leaf segments spreading.
1H. Heads about 4 mm. in diameter. .... 9. *A. laciniata*
2H. Heads about 9 mm. in diameter. ......10. *A. macrobotrys*
2F. Stem leaves entire or lobed, few.
1G. Plant 1 dm. or less tall; densely white-villous. ....11. *A. aleutica*
2G. Plants usually taller.
1H. Heads numerous, the phyllaries green. 2. *A. canadensis*
2H. Heads fewer; phyllaries gray pubescent on the back. .... 3. *A. borealis*

1. *A. dracunculus* L. Linear-leaved Wormwood.

A. dracunculoides Pursh.

Glabrous; stems woody, branched, 4–9 dm. tall; leaves linear, the lower often 3- or more-cleft, the others entire, up to 4 cm. long; heads numerous, nodding, about 3 mm. long and broad; phyllaries ovate, green with wide scarious margins.

South Alaska and Yukon southward and in Eurasia. Fig. 1027.

2. *A. canadensis* Michx. Canada Wormwood.

Plants with long taproot; stems 1 or few, 2–10 dm. tall; leaves glabrous to silky, divided into very narrow linear segments 0.5–2 mm. wide; heads numerous, suberect to nodding, 3–4 mm. long and at least as wide; phyllaries round-elliptic, green, with broad hyaline margins.

Central Alaska—Newf.—Vt.—Minn.—Colo.—Wash. Fig. 1028.

3. *A. borealis* Pall. Northern Wormwood.

Leaves mostly basal, minutely silky or glabrate, the ultimate segments linear-lanceolate; stems 1–several, 1–3 dm. tall; inflorescence a raceme or spike-like; heads 4–6 mm. broad, purplish to green; phyllaries pubescent to glabrate, with narrow scarious margins. The var. *purshii*

Bess. has smaller heads, is more permanently villous and the upper leaves mostly entire. Bering Strait—west Greenl.—Newf.—Gt. Lakes—Colo. also in north Asia. Fig. 1029.

4. *A. frigida* Willd. Prairie Sagewort.

Woody at the base, 2–5 dm. tall, whole plant silky-canescent, brownish in age; leaves 1–2 cm. long with linear-filiform divisions; heads numerous, nodding, racemose or racemose-paniculate, about 4 mm. broad.

Dry plains and hillsides, Alaska—L. Athabasca—Wisc.—Texas—Ariz. and in Eurasia. Fig. 1030.

5. *A. glomerata* Ledeb.

Caespitose and silky-villous; basal leaves 1–3 cm. long, 2- to 3-ternate; stem leaves few; stems 5–15 cm. tall; heads several in a capitate cluster, 5–6 mm. broad; phyllaries silky-villous, elliptical or oval with brown margins; disk corollas yellow, pubescent.

East Asia and Bering Sea and Arctic Coast districts of Alaska. Fig. 1031.

6. *A. senjavinensis* Bess.

Caespitose and silky-villous; leaves mostly basal, once or twice 3- to 5-fid, 5–15 mm. long, the lobes acutish; stems about 1 dm. tall; heads few or several in a capitate cluster, 4–5 mm. broad; phyllaries densely hirsute-villous on the back with dark margins; disk flower corollas yellow, glandular-glanduliferous. A beautiful species.

St. Lawrence Bay in Asia to Bering Strait region of Alaska. Fig. 1032.

7. *A. globularia* Cham.

Caespitose and silky-villous; leaves mostly basal, once or twice ternate, 1–3 cm. long; stems 5–12 cm. tall; heads several in a dense head, 5–8 mm. broad; phyllaries silky-hirsute with black or dark margins; corolla glabrous, yellow or pinkish.

East shore of Chuch Penin. in Asia—central Alaska. Fig. 1033.

8. *A. arctica* Less. Arctic Wormwood.

Glabrous or sparingly pubescent in the typical form; basal leaves petioled, 5–20 cm. long, twice or thrice pinnatifid; stems 2–6 dm. tall; heads several to many in a raceme, nodding, the lower on long peduncles, 7–10 mm. wide; phyllaries with green center and dark margins; corolla villous. A variable group. Var. *beringensis* Hult. of the Aleutians and Bering Sea region is lanate, the hairs of the inflorescence being rust-colored. Ssp. *comata* (Rydb.) Hult. of the Arctic Coast region is usually more or less lanate; stems 1–2 dm. tall; leaves with broad rachis and few short divaricate lobes.

East Asia—Yukon—Wash. Fig. 1034.

9. *A. laciniata* Willd.

More or less hirsute; lower leaves bipinnatifid; stem leafy, reddish-purple, 25–60 cm. tall; heads nodding, about 4 mm. broad; phyllaries light green with darker center and translucent scarious margins.
Globe on Livengood Highway and in Eurasia.

10. *A. macrobotrys* Ledeb.

Rootstock creeping; plant more or less hirsute-pilose; leaves mostly basal, petioled, bi- or tripinnatifid; stems 2–4 dm. tall, greenish or straw-colored; heads several to many, nodding, 5–6 mm. broad; phyllaries with light, scarious, erose margins.
Fairbanks and Ft. Selkirk and in Siberia. Fig. 1035.

11. *A. aleutica* Hult.

Caespitose and densely villous; leaves short-petioled, tripartite or pinnatisect; stems 2–5 cm. tall; heads few, about 5 mm. broad; outer phyllaries linear.
Middle Aleutians.

12. *A. trifurcata* Steph. var. *heterophylla* (Bess.) Kudo.

Caespitose and silky-villous or sericeous; basal leaves twice dissected into linear divisions; stems 1–2 dm. tall; heads in a spike-like raceme, 6–7 mm. broad; phyllaries densely villous; disk flowers yellow with glabrous or slightly pilose corollas.
East Asia—Coronation Gulf—Gt. Bear L.—Mt. McKinley Park. Fig. 1036.

13. *A. alaskana* Rydb.

Caespitose with woody rootstock; lower leaves pinnate with 5 divisions, white-tomentose on both surfaces; stems 2–5 dm. tall; inflorescence racemiform; heads nodding, 6–7 mm. broad; outer phyllaries villous-tomentose, the inner oval with scarious, erose margins.
Lake Kluane and Alaska. Fig. 1037.

14. *A. kruhsiana* Bess.
A. tyrrellii Rydb.

Silky-canescent, woody at the base; lower leaves twice pinnatifid with 3–5 primary divisions, the ultimate divisions spatulate or oblanceolate; stem leaves more simple, the uppermost simple; stems 2–4 dm. tall, branched; heads nodding, often on long peduncles, about 7 mm. broad; corollas glandular-glanduliferous and somewhat hairy.
East Asia to Yukon. Fig. 1038.

15. *A. gnaphaloides* Nutt.

Caespitose, white-tomentose throughout; stems 3–10 dm. tall; leaves

numerous, the lower oblanceolate, 5–10 cm. long, the upper linear; heads numerous in leafy panicles, densely tomentose, 2–3 mm. broad.

Bennett, probably introduced. Sask.—Ont.—Mo.—Colo.

16. *A. unalaskensis* Rydb.

Stems leafy, angled, striate, 3–12 dm. tall; leaves numerous, green and glabrate above, white-tomentose beneath, primary divisions usually 5, these again lobed and toothed, up to 1 dm. long and about as broad; heads numerous, in a leafy panicle, about 5 mm. long and wide; phyllaries ovate or oval, light green with scarious margins; corollas reddish-purple. The var. *aleutica* Hult. has narrower divisions of the leaves and the upper surface subtomentose-lanuginose.

Japan—Unalaska. Fig. 1039.

17. *A. tilesii* Ledeb.

Leafy perennial, striate; leaves sessile, 5–10 cm. long, acuminate, pinnatifid, soon glabrate above, white-tomentose beneath, the divisions 3–5, often again cleft or toothed; heads nodding in spike-like panicles; flowers yellowish-brown. A large and diverse group separable into 4 races as follows.

1A. Heads large, 6 – 8 mm. broad.
- 1B. Unbranched with few heads; upper leaves lobed; leaves with narrow median lobe. .... *A. tilesii*
- 2B. Taller and often branched with numerous heads; upper leaves entire; leaves with broad median lobe. .... *Ssp. unalaskensis* (Bess.) Hult.

2A. Heads smaller, 4 – 6 mm. broad.
- 1B. Leaves strongly dissected into narrow, acute divisions; inflorescence often branched. .... Ssp. *gormanii* (Rydb.) Hult.
- 2B. Upper leaves entire, inflorescence narrow. .... *Ssp. elatior* T. & G.

The typical form Eurasia—Alaska—Hudson Bay. Ssp. *elatior* Alaska and Yukon—Mont.—Ore. Ssp. *gormanii* central Alaska south and west to Naknek. Ssp. *unalaskensis* Cordova and Mt. McKinley Park—Nome—Aleutians. Fig. 1040.

18. *Artemisia* sp.

What may be an undescribed species occurs on the sandy shores of Lake Kluane. It is subfruticose, 2–4 dm. tall, silvery-canescent throughout; lower leaves 2-pinnatisect or often only deeply 3-fid at the apex; upper leaves simple; heads about 5 mm. broad; phyllaries densely wooly.

17. TANACETUM (Tourn.) L.

Strongly aromatic leafy perennials; leaves alternate, 1- to 3-pinnatifid; heads radiate but the rays inconspicuous; involucres hemispheric or

depressed; receptacle convex, naked; achenes ribbed and with a flat top; pappus a short crown. (Name of uncertain derivation.)

1A. Heads numerous; introduced. .... 3. *T. vulgare*
2A. Heads solitary or few; native.
  1B. Heads 1 – 3, usually solitary. .... 1. *T. bipinnatum*
  2B. Heads usually more than 1. .... 2. *T. huronense*

1. *T. bipinnatum* (L.) Schultz-Bip.

Stems 2–5 dm. tall, striate, hirsute; leaves up to 2 dm. long, the primary divisions up to 5 cm. long; involucres 15–20 mm. broad; phyllaries hirsute, with brown scarious margins; corollas 4 mm. long; achenes 3 mm. long; pappus a 3- to 5-lobed crown.

Central Alaska west through Asia. Fig. 1041.

2. *T. huronense* Nutt.

Very similar to *T. bipinnatum* but with a larger number of smaller heads and with shorter ray flowers.

Central Alaska—Que.—Newf.—Maine—Mich.

3. *T. vulgare* L. Common Tansy.

Stems stout, glabrous, 5–9 dm. tall; leaves pinnately divided, 1–3 dm. long; leaflets pinnatifid; heads numerous, 1 cm. or less broad.

Adventitive in southeast Alaska. Native of Europe and widely naturalized. Fig. 1042.

18. COTULA L.

Low marsh plants with opposite leaves; heads discoid with a narrow row of marginal pistillate flowers; receptacle with short pedicels from which the achenes are deciduous; pappus not evident; achenes glabrous, compressed. (Greek, small cup, in allusion to the bases of the clasping leaves.)

C. coronopifolia L. Mud-Disk.

Decumbent and slightly fleshy; stems about 1 dm. tall; lower leaves toothed, the upper leaves reduced and lanceolate with entire margins; heads about 8 mm. broad, borne on slender peduncles; achenes smooth on convex side, white-papillose on slightly concave surface.

Tidal flats, southeast Alaska. Widely distributed along the shores of both hemispheres.

19. PETASITES L.

Perennial herbs with thick creeping rootstocks; leaves basal, petioled, broad, reniform, cordate, triangular or sagittate, tomentose beneath; flowering stems scaly, scape-like, preceding the leaves; heads

many-flowered, white or purplish, corymbose, some heads with fertile ray flowers and sterile tubular ones, others with all pistillate and fertile flowers; achenes narrow, 5- to 10-ribbed; pappus of soft white capillary bristles. (Greek, a broad brimmed hat in allusion to the large leaves.)

1A. Leaves lobed ¾ or more of the way to the base. ..... 5. *P. palmata*
2A. Leaves sagittate, the margins merely serrate. .... 1. *P. sagittata*
3A. Leaves somewhat lobed but not more than about ½ way to the base.
  1B. Leaves lobed about ½ way to the base.
    1C. Leaves thin. .... 4. *P. vitifolius*
    2C. Leaves thick. .... 3. *P. hyperboreus*
  2B. Leaves scarcely lobed to lobed ¼ way to the base. 2. *P. frigidus*

1. *P. sagittatus* (Banks) Gray. Arrow-leaf Sweet Coltsfoot.

Scapes 2–4 dm. tall, floccose; scales lanceolate, attenuate, 5–8 cm. long; petioles of leaves 1–4 dm. long, white tomentose; leaves up to 2 dm. long, the under surface white-tomentose, the upper surface becoming glabrate in age. Easily determined by the mature leaf.

Central Alaska—Labr.—Minn.—Colo.—B.C. Fig. 1043.

2. *P. frigidus* (L.) Fries. Arctic Sweet Coltsfoot.

Stems 2–4 dm. tall, floccose, with lanceolate scales 5–8 cm. long, often bearing a small blade; leaves 5–13 by 5–15 cm., sometimes slightly longer than broad, on petioles 1–2 dm. long; involucres about 1 cm. high; flowers nearly white, fragrant. Seems to hybridize with *P. hyperboreus* and *P. sagittatus*.

Throughout Alaska and Yukon—Mack.—B.C. and in Eurasia. Fig. 1044.

3. *P. hyperboreus* Rydb.

Stems 1–3 dm. tall, floccose; scales lanceolate, 3–6 cm. long, sometimes with the suggestion of a blade at the tip; leaves reniform to deltoid, 5–15 cm. long, 8–20 cm. wide, on petioles 5–15 cm. long; involucres about 1 cm. long in the pistillate flowers; achenes 2 mm. long; pappus in flower 3–5 mm. long, in fruit 14–18 mm. long.

Alaska and Yukon—Hudson Bay—Alta.—Wash. Fig. 1045.

4. *P. vitifolius* Greene.

Leaves reniform to cordate-deltoid, 5–25 cm. broad, cut about half way to the base into divergent lobes, white-tomentose beneath, on petioles 1–3 dm. long; stems 12–60 cm. tall; achenes about 1 mm. long.

Yukon—Labr.—Que.—Minn.—Alta.

5. *P. palmatus* (Ait.) Gray.

Stems 15–60 cm. tall; leaves palmately 5- to 9-cleft from two thirds to almost the base, 7–20 cm. long and wide; involucres about 1 cm. high; flowers creamy white.

South Yukon—Newf.—N. Y.—Minn.—B. C. Fig. 1046.

20. ARNICA L.

Perennial herbs with opposite leaves and peduncled heads; ray flowers usually present and fertile; involucre campanulate or turbinate with the phyllaries in one or two subequal series; corollas yellow; receptacle flat, villous or fibrillate; disk flowers perfect, fertile, the corollas 5-lobed, the style with reflexed branches; achenes 5- to 10-ribbed; pappus of one whorl of rather rigid, usually barbellate bristles. (Derivation uncertain.)

1A. Anthers yellow.
  1B. Pappus white.
    1C. Leaves lanceolate or oblanceolate.
      1D. Achenes lanate-pilose. .... 1. *A. alpina*
      2D. Achenes glabrous or subglabrous below. ...... 2. *A. louiseana*
    2C. Leaves ovate, obovate or orbicular.
      1D. Lower leaves distinctly cordate. .... 4. *A. cordifolia*
      2D. Lower leaves truncate or wide-cuneate at the base. .... 3. *A. latifolia*
  2B. Pappus tawny or stramineous.
    1C. Phyllaries usually obtuse, the tips pilose within. 5. *A. chamissonis*
    2C. Phyllaries acute, the tips not pilose within.
      1D. Stem leaves 4–10 pairs.
      2D. Stem leaves 3 or 4 pairs. .... 6. *A. amplexicaulis*
        1E. Basal leaf blades broadly ovate or subcordate. 7. *A. diversifolia*
        2E. Lower leaves oblanceolate, short petioled. ... 8. *A. mollis*
        3E. Lower leaves petioled, ovate or ovate-oblong. 9. *A. parrui*
2A. Anthers purple.
  1B. Heads nodding, leaves mostly basal. ....10. *A. lessingii*
  2B. Heads erect; stem leafy. ....11. *A. unalaskensis*

1. *A. alpina* (L.) Olin.

Stems single or seldom several, arising from a loose crown, 10–45 cm. tall, thinly to densely villous or hirsute; lower leaves 3- to 5-nerved, oblanceolate with winged petioles; stem leaves 1–4 pairs, lanceolate; heads 15–22 mm. high, usually somewhat broader than high; phyllaries 10–20 in 2 series; achenes densely hirsute. Represented in our area by 2 subspecies. Ssp. *angustifolia* (Vahl) Mag. (*A. angustifolia* Vahl) of the Arctic is 5–15 cm. tall with narrow leaves and bearing a single head. Ssp. *attenuata* (Greene) Mag. (*A. attenuata* Greene) is 15–45 cm. tall with 3–7 heads. Var. *linearis* Hult. has linear leaves. Var. *vestita* Hult. has the whole plant cinereous-pubescent.

Alaska—Ellesmereland—Greenl.—Mont.—B. C. and in Eurasia. Fig. 1047.

2. *A. louiseana* Farr. ssp. *frigida* (Meyer) Mag.

A. nutans Rydb. *A. sancti-laurentii* Rydb. *A. brevifolia* Rydb.
A. mendenhallii Rydb. *A. illiamnae* Rydb.

Stems 5–35 cm. tall, leafy to the middle, usually reddish at the base; leaves oblanceolate or elliptic to elliptic-lanceolate, glabrate to sparsely hispidulous-puberulent, the margins entire or usually some of them toothed; heads 1, rarely 2 or 3, nodding in anthesis, erect in fruit;

phyllaries 10–18, 9–14 mm. long, tinged reddish-purple; achenes usually glabrous below, sparsely hispid at the summit. Var. *pilosa* Mag. is a pilose form.

East Siberia, most of Alaska and Yukon to north B. C. The type is from Lake Louise in the Canadian Rockies. Fig. 1048.

3. *A. latifolia* Bong.

A. betonicaefolia Greene.

Rootstock horizontal; stems 2–6 dm. tall, sparingly hairy below, more densely so in the inflorecence; stem leaves 2–5 pairs, the lower ovate to elliptic-lanceolate and petioled, the upper sessile; heads 1–5; involucre 12–15 mm. long and wide, finely villous; achenes striate, from glabrous to glandular and a few hairs at the apex.

Southwest coast of Alaska—central Alaska—Colo.—Calif. Fig. 1049.

4. *A. cordifolia* Hook.

Stems usually simple, 15–45 cm. tall, glandular-pubescent; cauline leaves 2 or 3 pairs, the lower ovate to lanceolate, cordate at the base, glandular-puberulent, the upper reduced; heads 1–3, rarely more, large, 18–25 mm. high; phyllaries 14–18 mm. long, more or less ciliate; achenes 6.5–8 mm. long, uniformly but not densely hirsute.

Southeast Alaska—Yukon—N. Mex.—Calif. Fig. 1050.

5. *A. chamissonis* Less.

A. kodiakense Rydb.

Stems solitary, usually unbranched, 2–8 dm. tall, striate, variously pubescent, red tinged toward the base; cauline leaves 4–10 pairs, but little reduced above, all sessile or the lowermost petioled, lanceolate to oblanceolate, often connate at the base; heads 3–15, 12–18 mm. high; phyllaries conspicuously pilose at the tip; pappus subplumose; achenes 4.5–6 mm. long, tapering to the base, sparsely hirsute. The subsp. *foliosa* (Nutt.) Mag. is seldom red tinged; the pubescence is not moniliform; pappus barbellate, lower cauline leaves long petioled.

Aleutians—Mack.—Mont.—Utah—N. Mex.—Calif. Fig. 1051

6. *A. amplexicaulis* Nutt.

Stems 20–75 cm. tall, simple, branched only in the inflorescence, subglabrous to scabrid-glandular, the pubescence dense in the inflorescence; cauline leaves 4–10 pairs, elliptic-lanceolate, inconspicuously to strongly and sharply serrate-dentate, acute, all but the lowermost sessile; heads 10–15 mm. high; phyllaries 10–12 mm. long; achenes 4.5–6 mm. long, sparingly hirsute.

South Alaska—Mont.—Calif. Fig. 1052.

7. *A. diversifolia* Greene.

Stems simple, 15–40 cm. tall, the herbage usually pale green;

cauline leaves usually 3 pairs, the middle pair the largest, ovate to elliptic, more or less irregularly serrate-dentate, 4–8 cm. long, 25–60 mm. wide, mostly with winged petioles shorter than the blades; heads usually 3–5; achenes 5.5–6.5 mm. long, strongly angled, scantily short-hispidulous or hispid.

South Alaska—Alta.—Mont.—Calif.

8. *A. mollis* Hook.

Stems 3–6 dm. tall, sparingly crisp-hairy, glandular-hirsute in the inflorescence; lower leaves oblanceolate, the upper lanceolate, usually denticulate, pubescent on both surfaces; heads 1–3; phyllaries acuminate; achenes 5 mm. long, sparingly hirsute; pappus about 6 mm. long, light brown.

Yukon—Alta.—Colo.—Calif.

9. *A. parryi* Gray.

Stems 3–6 dm. tall, somewhat villous, glandular above; basal leaves petioled, the blades ovate or lanceolate, 3–10 cm. long, somewhat villous on both surfaces, the uppermost reduced; heads 3–20, usually nodding in anthesis; ray flowers usually wanting; pappus about 1 cm. long.

Yukon—Alta.—N. Mex.—Ore.

10. *A. lessingii* (T. & G.) Greene.

Rootstock horizontal; stems 1–3 dm. tall, villous with brown hairs; basal leaves small; stem leaves 2–4 pairs, mostly near the base, oblong, elliptic or oblanceolate, nearly smooth below, ciliate on the margins, 4–7 cm. long, 5–20 mm. wide; head solitary, nodding; involucre densely villous; rays about 2 cm. long; achenes nearly glabrous and striate; bristles light brown and barbellate. The subsp. *norbergii* Hult. & Mag. is taller growing and has 5–6 pairs of stem leaves.

Kamchatka—Arctic Alaska—Yukon—north B. C. Fig. 1053.

11. *A. unalaskensis* Less.

Rootstock covered by the fuscous fibrous remains of old leaves; stems 1–3 dm. tall, striate, villous and glandular-puberulent; cauline leaves about 3 pairs; lower leaves oblanceolate changing in the upper to lanceolate, 3- to 5-ribbed, hairy on both surfaces; heads solitary; involucre about 12 x 20 mm. phyllaries 3-nerved; achenes hirsute; bristles light brown and strongly barbellate.

Aleutians and the islands of Bering Sea to Japan. Fig. 1054.

21. CACALIA L.

Tall glabrous perennials; leaves alternate and petioled; heads rather small, discoid; involucre of 5 nearly equal bracts, usually with a few

shorter outer ones; pappus of white bristles; achenes glabrous. (Ancient Greek name.)

C. auriculata DC.

Plant tall, the stem curved at each node; leaves reniform, the base cordate, the margins very unequally serrate, up to 25 cm. wide; inflorescence spike-like; heads about 1 cm. long.

East Asia and west Aleutians. Fig. 1055.

22. SENECIO (Tourn.) L.

Annual or perennial herbs with alternate or basal leaves; heads several or numerous, occasionally solitary, radiate or discoid, yellow; involucre cylindric or campanulate; phyllaries in one series often with smaller ones at the base; receptacle flat, naked, often pitted; achenes 5- to 10-ribbed; pappus of copious soft capillary bristles. (Senex, an old man, in allusion to the white pappus.)

1A. Involucre scales in a single row.
  1B. Annual or biennial. .... 1. *S. congestus*
  2B. Perennials.
    1C. Phyllaries pubescent.
      1D. Heads solitary, phyllaries with purplish or brown pubescence. .... 2. *S. atropurpureus*
      2D. Heads usually more than 1; phyllaries with gray or yellowish pubescence.
        1E. Leaves floccose on both surfaces. .... 3. *S. fuscatus*
        2E. Leaves pubescent below only. .... 4. *S. yukonensis*
    2C. Phyllaries glabrous.
      1D. Heads solitary or stem branched, each branch with 1 head.
        1E. Achenes hirtellous. .... 5. *S. hyperborealis*
        2E. Achenes glabrous.
          1F. Stem usually simple, glabrous or slightly tomentose at the base. .... 6. *S. resedifolius*
          2F. Stem usually branched with markedly tomentose base. .... 7. *S. conterminus*
      2D. Heads in corymbose cymes.
        1E. Heads discoid.
          1F. Disk flowers red. .... 8. *S. pauciflorus*
          2F. Disk flowers yellow. .... 9. *S. indecorus*
        2E. Heads radiate.
          1F. Ligules short. ....10. *S. cymbalarioides*
          2F. Ligules long. ....11. *S. pauperculus*
2A. Involucral scales in 2 or more series or with outer scales at the base of the involucre.
  1B. Introduced annual weed. ....17. *S. vulgaris*
  2B. Native perennials.
    1C. Leaves pinnately or subpalmately divided. ......12. *S. palmatus*
    2C. Leaves not divided.
      1D. Phyllaries black-tipped. ....13. *S. lugens*
      2D. Phyllaries not black-tipped.
        1E. Heads including rays 2–3 cm. in diameter.
          1F. Leaves elongated-deltoid. ....14. *S. triangularis*
          2F. Leaves ovate. ....15. *S. sheldonensis*
        2E. Heads 5–6 cm. in diameter. ....16. *S. pseudo-arnica*

1. *S. congestus* (R. Br.) DC. var. *palustris* (L.) Fern. Marsh-Fleabane.

Stems simple, stout, hollow, 2–7 dm. tall; leaves linear to oblong-lanceolate, dentate to shallowly pinnatifid; corymb dense and villous-lanate; rays yellow, short; mature pappus four to five times as long as the smooth achene.

Circumpolar, south to Alta. and the north shore of the Great Lakes. Fig. 1056.

2. *S. atropurpureus* (Ledeb.) B. Feditsch.

Stems 1–2 dm. tall, tomentose when young, often becoming glabrate in age; lower leaves ovate to obovate. A varied group giving rise to well-marked races. The typical form found in the Bering Sea region to Point Hope has comparatively wide leaves and large head with long rays. Var. *tomentosus* (Kjellm.) Hult. (*S. kjellmanii* Porsild) has pointed lower leaves and densely black-wooly involucre. Var. *dentatus* Gray has all the leaves conspicuously dentate, the lower leaves being lanceolate to oblong. Subsp. *frigidus* (Rich.) Hult. is the most common and widespread form; the lower leaves are less developed than in the type; the heads rather smaller and either radiate or discoid.

Circumpolar, south to Labr., Mack., Yukon, and Alaska. Fig. 1057.

3. *S. fuscatus* (Jord. & Fourr.) Hayek.
S. lindstroemii (Ostf.) Porsild. *S. denali* A. Nels.

Stems 10–25 cm. tall, more or less floccose; basal leaves obovate, petioled, floccose-tomentose beneath, glabrate in age; heads 1–5; phyllaries narrow, acuminate, purple; rays orange, sometimes with purplish tinge; achenes sparingly strigose-hirsute.

Bering Sea and Arctic coast to Mack. and in Eurasia. Fig. 1058.

4. *S. yukonensis* Porsild.
S. alaskanus Hult.

Stems 1–3 dm. tall, floccose-pilose, yellowish lanate in the inflorescence; basal leaves elliptic to lanceolate, entire or remotely sinuate-dentate, green above, white-tomentose beneath; heads 2–6, densely aggregated; phyllaries narrowly lanceolate, purplish with profuse yellowish indument; achenes glabrous.

Bering Strait—Arctic Coast—Yukon—Alaska Range. Fig. 1059.

5. *S. hyperborealis* Greenm.

Stems 1 to several, 1–2 dm. tall, simple or branched; lower leaves obovate and crenately margined to pinnately divided, 4–10 cm. x 10–25 mm.; stem leaves pinnatisect; heads radiate, the involucre glabrous;

achenes hispid on the margins, often puberulent on the sides.
Alaska, Yukon and Mack. Fig. 1060.

6. *S. resedifolius* Less.

Stems simple or branching from the base, 5–15 cm. tall, smooth, striate; lower leaves with broad lobe at the top and usually one pair of small lobes below; stem leaves much reduced; heads solitary, about 1 cm. high; phyllaries acute, decidedly purple; achenes glabrous.
Circumpolar, south to Newf., Gaspe Penin., Mont., Colo. Fig. 1061.

7. *S. conterminus* Greenm.

Quite variable; stems usually branched, 1–4 dm. tall, sometimes caespitose, more or less white-floccose; lower leaves ovate to spatulate, crenate-dentate to lobed; heads solitary at the ends of the branches, radiate; involucre floccose at the base, glabrous above; achenes glabrous.
Alaska—Yukon—Alta.—B.C. Fig. 1062.

8. *S. pauciflorus* Pursh.

Stems glabrous, 1–6 dm. tall; leaves thick and fleshy, the basal one long-petioled, elliptical to reniform, coarsely dentate, 15–40 mm. long; cauline leaves sessile with mostly obtuse pinnatifid lobing; heads 1–6, rarely more; phyllaries usually purple; disk corollas with red or red-orange lobes; achenes plump, glabrous.
Yukon—Gt. Bear L.—Sask.—Labr.—Newf.—Wyo.—Calif.

9. *S. indecorus* Greene.

Stems glabrous or glabrescent, 2–10 dm. tall; leaves membranous, the basal oblong, elliptical or rounded, dentate to lacerate; blades of basal leaves 2–7 cm. long on slender petioles; cauline leaves becoming lacerate-pinnatifid upward; heads 5–20; phyllaries green or with purple tips; achenes strongly ribbed, 2–3 mm. long.
Central Alaska—Gt. Slave L.—Que.—Mich.—Mont.—Ida.—Calif. Fig. 1063.

10. *S. cymbalarioides* Nutt.

Stems clustered, glabrous except in the axils and base of the petioles, 1–4 dm. tall; lower leaves entire or dentate toward the apex, glabrous, on petioles 1–8 cm. long; heads few to many, radiate; phyllaries 5–8 mm. long; achenes glabrous. A low-growing northern form with narrow leaves and small stem leaves is var. *borealis* (T. & G.) Greenm.
Yukon—Gt. Slave L.—Utah—N. Mex.

11. *S. pauperculus* Michx.

Stems 1–6 dm. tall, glabrous or glabrescent and frequently with

flocculent tufts of white wool; basal leaves oblanceolate, spatulate or oblong-elliptic, crenate or crenate-dentate; upper stem leaves pinnatifid; heads 2–40, 5–9 mm. high; phyllaries greenish, rarely purple-tipped, glabrous or glabrescent.

Alaska—Gt. Bear L.—Labr.—Newf.—Va.—Mo.—Colo.—Ida.—B.C. Fig. 1064.

12. *S. palmatus* (Pall.) Ledeb.

Stems glabrous, from horizontal rhizomes, up to 15 dm. tall, leafy; leaves up to 20 cm. long, very deeply palmately lobed into 5 lanceolate lobes prominently and irregularly toothed; heads numerous in a dense corymb; pappus brown.

An Asiatic species found on Attu Isl. Fig. 1065.

13. *S. lugens* Rich.

Stem rather stout, 2–7 dm. tall, wooly when young becoming glabrate in age; basal leaves narrowly oblanceolate, sinuate-dentate; upper stem leaves much reduced and becoming linear or linear-lanceolate; heads several or numerous, in a close corymb, about 8 x 8 mm. phyllaries conspicuously black-tipped.

Alaska—Coronation Gulf—Man.—Wash. Fig. 1066.

14. *S. triangularis* Hook.

Stems several from the same clump, 5–15 dm. tall, leafy to the summit; leaves elongate-triangular, 5–20 cm. long, dentate with triangular teeth; heads several to many; involucres about 8 x 8 mm.; phyllaries linear.

South Alaska—Yukon—Sask.—Mont.—N. Mex.—Calif. Fig. 1067.

15. *S. sheldonensis* Porsild.

Stems glabrous, slender, 3–4 dm. tall, bearing about 10 leaves; leaves broadly lanceolate, glabrous, repand-denticulate, the lower petioled, the upper sessile or clasping and reduced; heads 3 or 4, long-peduncled, turbinate; phyllaries with hyaline margins and attenuate, dark-colored, pubescent tips; achenes glabrous.

Mt. Sheldon in Yukon.

16. *S. pseudo-arnica* Less.

Stems stout, 1–10 dm. tall, very leafy; leaves spatulate to oblanceolate, 6–15 cm. long, densely fine-wooly beneath, glabrous and rugose above; heads 1 to several, large, on short peduncles; achenes smooth; pappus dull.

Beaches, except the Arctic and south to Vancouver Isl. and in Asia and east America. Fig. 1068.

17. *S. vulgaris* L. Common Groundsel.

Stems 1–4 dm. tall, branched; lower leaves petioled, the upper ones sessile or clasping, usually wooly in the axils; leaves undulate to pinnatifid-lobed, rather fleshy; heads several or numerous, about 8 mm. high; phyllaries, especially the smaller ones at the base, black-tipped.

An introduced weed; native of Europe.

23. SAUSSUREA DC.

Perennial herbs with heads of purplish flowers which are all perfect; involucre of several series of imbricated bracts; anther tails ciliate; pappus double, the outer of short, rigid bristles, the inner of stout plumose bristles united at the base. (de Saussure was a Swiss botanist.)

1A. Leaves broad, regularly serrate. .... 1. *S. americana*
2A. Leaves lanceolate to linear, entire or with a few teeth.
  1B. Phyllaries of different lengths and regularly imbricate. .... 2. *S. angustifolia*
  2B. Most of the phyllaries of nearly equal length with shorter ones at the base.
    1C. Plant usually more than 1 dm. tall. .... 3. *S. nuda*
    2C. Plant less than 1 dm. tall. .... 4. *S. vicida*

1. *S. americana* D. C. Eaton.

Stems 4–10 dm. tall; lower leaves petioled and cordate or ovate; upper leaves lanceolate and nearly sessile; heads in a dense panicle; involucres about 12 x 8 mm., pubescent; phyllaries deltoid-ovate, the inner with dark margins.

Alpine meadows, southeast Alaska—Ida.—Ore. Fig. 1069.

2. *S. angustifolia* (Willd.) DC.

Stems 1–4 dm. tall, leafy, sometimes purple-tinged; leaves narrowly lanceolate to linear, entire or remotely dentate, glabrous to floccose; phyllaries acute, in 3 or 4 rows.

East Asia—Alaska—Yukon—Kewatin—Sask. Fig. 1070.

3. *S. nuda* Ledeb.
S. subsinuata Ledeb.

Stems 1–3 dm. tall; leaves wider than in *S. angustifolis* and usually repand-denticulate; receptacle naked; inflorescence dense.

East Asia and west Alaska. Fig. 1071.

4. *S. vicida* Hult.

Plants low, 2–15 cm. tall; lower leaves elliptic-lanceolate, entire or

remotely denticulate, sessile or short-petioled, viscid pubescent; heads densely aggregated; receptacle squamate; phyllaries attenuate-triangular. The typical form is found in the Bering Sea district only. Var. *yukonensis* (Porsild) Hult. is less markedly viscid-pubescent.

East Asia—Alaksa—Canadian Rockies. Fig. 1072.

24. CIRSIUM (Tourn.) Mill.

Stout biennial or perennial herbs; leaves alternate with lobes or teeth ending in spines; heads discoid, the flowers usually purple; phyllaries in many series, prickly-tipped; pappus one series of plumose bristles united at the base and falling away together. (Greek, referring to the use of the thistle as a remedy for swollen joints.)

1A. Perennial; heads small, 2 cm. high or less. .... 1. *C. arvense*
2A. Biennials; heads larger.
  1B. All phyllaries spine-tipped. .... 2. *C. vulgare*
  2B. Inner phyllaries unarmed.
    1C. Tips of inner phyllaries dilated or twisted. ..... 3. *C. foliosum*
    2C. Tips of inner phyllaries not dilated or twisted.
      1D. Leaves arachnoid-pubescent below. .... 4. *C. edule*
      2D. Leaves pilose on the nerves below not arachnoid-pubescent. .... 5. *C. kamtschaticum*

1. *C. arvense* (L.) Scop. Canada Thistle.

Perennial from creeping rootstocks; stems 3–10 dm. tall, branched above; heads numerous, campanulate; flowers purple, rarely white.

Has become established as a weed in several places, native of Europe.

2. *C. vulgare* (Savi) Tenore. Common or Bull Thistle.
C. lanceolatum Auct.

Stems stout, 1–2 m. tall; leaves dark green, pinnatifid, the apex and triangular-lanceolate lobes tipped with long, stout prickles; phyllaries cottony, lanceolate, all tipped with prickles.

Introduced weed, native of Eurasia.

3. *C. foliosum* (Hook.) DC.

Stems 2–6 dm. tall, more or less arachnoid-hairy; leaves light green, from rather deeply pinnatifid to almost entire, the spines rather weak and yellowish; inner phyllaries with erose, scarious tips; corollas pale.

Yukon—S. Dak.—Colo.—Utah—B. C. Fig. 1073.

4. *C. edule* Nutt. Edible Thistle.

Stems lightly pubescent-arachnoid, 1–2 m. tall; leaves pinnately cleft, the divisions 2- to 3-lobed, weakly spiny; heads solitary or 2 or 3;

phyllaries lanceolate, acuminate; corollas usually purple, sometimes pale.
Hyder—Nev.—Calif.

5. *C. kamtschaticum* Ledeb. Kamchatka Thistle.

Plant tall, up to 2 m. or more; leaves oblong-ovate or oval, deeply dentate to incisely pinnatifid, 8–25 cm. long, weakly prickly, the lower decurrent on the stem with prickly wings; heads one or few; phyllaries all attenuate-subulate from a narrow base.

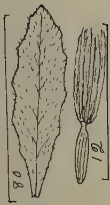
An Asiatic species found in the western Aleutians. Fig. 1074.

PLATE XLI

Scale in millimeters.

FIG.

951. *Picris hieracoides kamtschatica* (Ledeb.) Hult. Leaf and fruit.
952. *Apargidium boreale* (Bong.) T. & G. Leaf and fruit.
953. *Taraxacum kamtschaticum* Dahlst. Leaf, achene and phyllaries.
954. *Taraxacum andersonii* Hagl. Leaf, phyllaries and achene.
955. *Taraxacum eyerdamii* Hagl. Leaves and phyllaries.
956. *Taraxacum integratum* Hagl. Leaf, phyllaries and achene.
957. *Taraxacum lacerum* Greene. Leaf, achene and outer phyllary.
958. *Taraxacum lateritium* Dahlst. Leaf, achene and outer phyllary.
959. *Taraxacum scotostigma* Hagl. Leaf, achene and outer phyllary.
960. *Taraxacum trigonolobium* Dahlst. Leaf, achene and outer phyllary.
961. *Taraxacum alaskanum* Rydb. Leaf, achene and outer phyllary.
962. *Agoseris scorzoneraefolia* (Schrad.) Greene. Leaf and achene.
963. *Agoseris aurantiaca* (Hook.) Greene. Leaf and achene.
964. *Sonchus oleraceus* L. Leaf and achene.
965. *Sonchus asper* (L.) All. Leaf and achene.
966. *Lactuca spicata* (Lam.) Hitchc. Leaf and achene.
967. *Prenanthes alata* (Hook.) Dietrich. Leaf and achene.
968. *Crepis elegans* Hook. Leaf and achene.
969. *Crepis nana* Rich. Leaf and achene.
970. *Hieracium albiflorum* Hook. Leaf and phyllary.
971. *Hieracium gracile* Hook. Leaf and phyllary.
972. *Hieracium triste* Cham. Leaf and phyllary.
973. *Solidago multiradiata* Ait. Leaves, flower and phyllary.
974. *Solidago elongata* Nutt. Leaf, flower and phyllary.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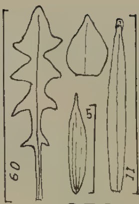
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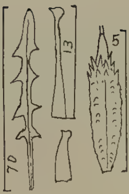
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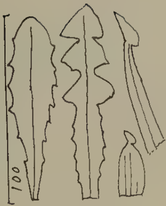
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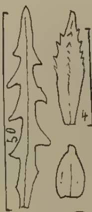
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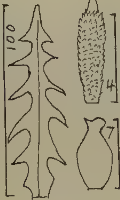
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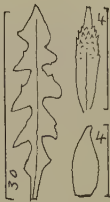
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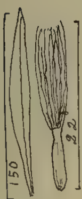
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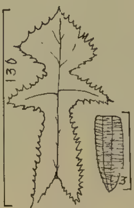
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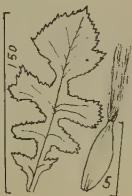
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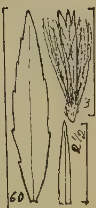
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PLATE XLII

Scale in millimeters.

Fig.

975. *Solidago lepida* Nutt. Leaf, flower and phyllary.
976. *Solidago decumbens* var. *oreophila* (Rydb.) Fern. Leaf, flower and phyllary.
977. *Aster alpinus* L. Leaf, phyllary and achene.
978. *Aster yukonensis* Cronq. Leaf, ray flower and phyllary.
979. *Aster junceus* Ait. Leaf, ray flower and phyllary.
980. *Aster subspicatus* Nees. Leaf, ray flower and phyllary.
981. *Aster sibiricus* L. Leaf, ray flower and phyllary.
982. *Aster modestus* Lindl. Leaf, ray flower and phyllary.
983. *Erigeron peregrinus* (Pursh) Greene. All *Erigerons* are leaf, ray flower and phyllary.
984. *Erigeron glabellus pubescens* (Hook.) Cronq.
985. *Erigeron caespitosus* Nutt.
986. *Erigeron yukonensis* Rydb.
987. *Erigeron grandiflorus* Hook.
988. *Erigeron hyperboreus* Greene.
989. *Erigeron uniflorus eriocephalus* (J. Vahl) Cronq.
990. *Erigeron humilis* Grah.
991. *Erigeron purpuratus* Greene.
992. *Erigeron compositus* Pursh.
993. *Erigeron lonchophyllus* Hook.
994. *Erigeron acris* var. *asteroides* (Andriz.) DC.
995. *Antennaria pulcherrima* (Hook.) Greene. Leaf and flowers.
996. *Antennaria howellii* Greene. Leaf and inner phyllary.
997. *Antennaria philonipha* Porsild. Stem and basal leaves and phyllaries.
998. *Antennaria monocephala* DC. Leaves and flower.

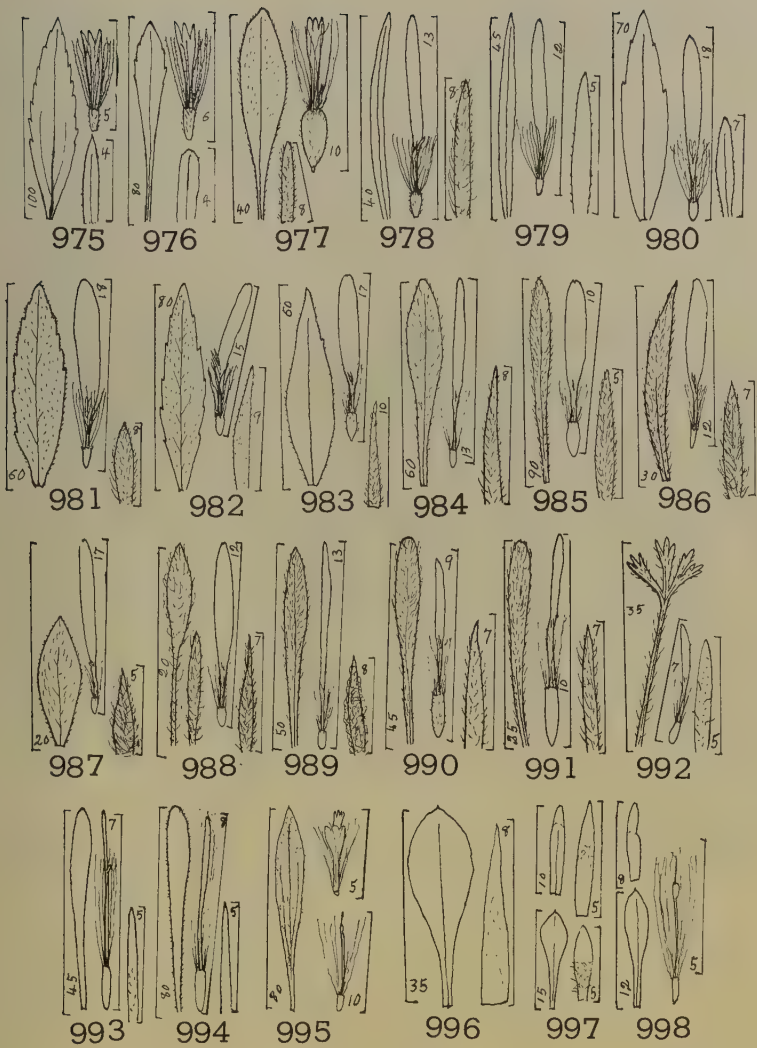
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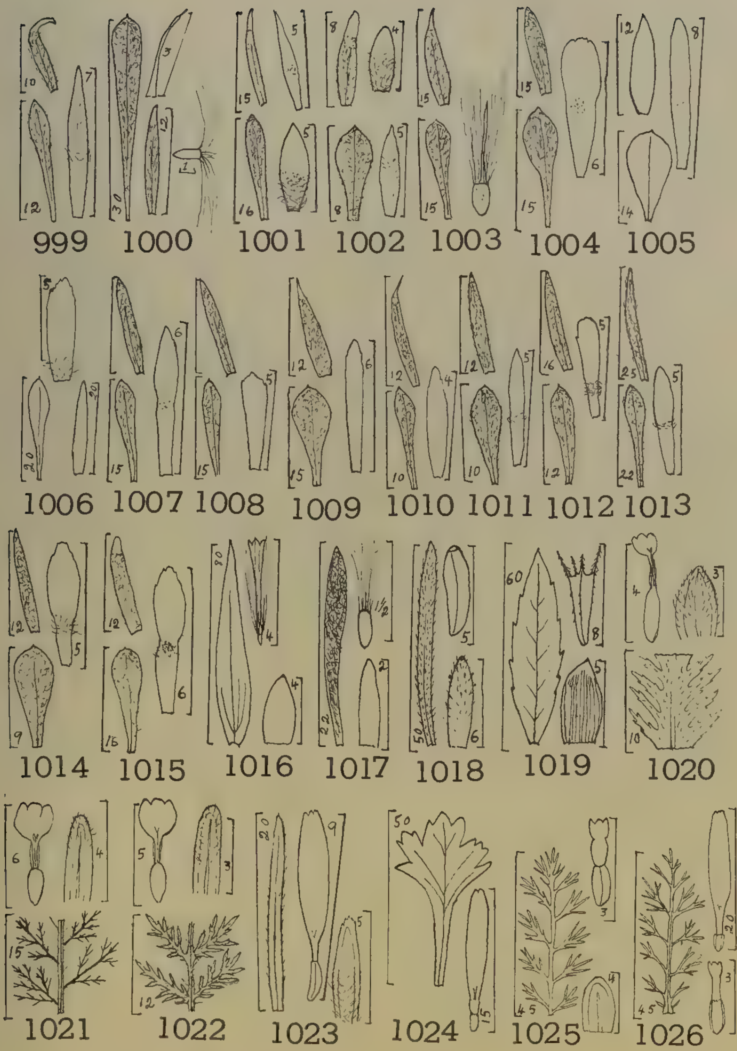
PLATE XLIII

Scale in millimeters.

FIG.

999. *Antennaria angustata* Greene. Leaves and inner phyllary.
1000. *Antennaria alaskana* Malte. Leaves, corolla and achene.
1001. *Antennaria ekmaniana* Porsild. Leaves and phyllaries.
1002. *Antennaria compacta* Malte. Leaves and phyllaries.
1003. *Antennaria stolonifera* Porsild. Leaves and achene.
1004. *Antennaria pallida* E. Nels. Leaves and phyllary.
1005. *Antennaria dioica* (L.) Gaertn. Leaves and phyllary.
1006. *Antennaria alborosea* Porsild. Phyllary and leaves.
1007. *Antennaria elegans* Porsild. Leaves and phyllary.
1008. *Antennaria rosea* (Eaton) Greene. Leaves and phyllary.
1009. *Antennaria oxyphylla* Greene. Leaves and phyllary.
1010. *Antennaria incarnata* Porsild. Leaves and phyllary.
1011. *Antennaria laingii* Porsild. Leaves and phyllary.
1012. *Antennaria nitida* Greene. Leaves and Phyllary.
1013. *Antennaria leuchippi* M. P. Porsild. Leaves and phyllary.
1014. *Antennaria subviscosa* Fern. Leaves and phyllary.
1015. *Antennaria isolepis* Greene. Leaves and phyllary.
1016. *Anaphalis margaritacea* (L.) Benth. & Hook. Leaf, flower and phyllary.
1017. *Gnaphalium uliginosum* L. Leaf, achene and phyllary.
1018. *Madia glomerata* Hook. Leaf, achene and outer phyllary.
1019. *Bidens cernua* L. Leaf, achene and phyllary.
1020. *Achillea sibirica* Ledeb. Ray flower, phyllary and section of leaf.
1021. *Achillea borealis* Bong. Ray flower, phyllary and section of leaf.
1022. *Achillea lanulosa* Nutt. Ray flower, phyllary and section of leaf.
1023. *Chrysanthemum integrifolium* Rich. Leaf, ray flower and phyllary.
1024. *Chrysanthemum arcticum* L. Leaf, ray flower.
1025. *Matricaria suaveolens* (Pursh) Rydb. Leaf, achene with corolla and phyllary.
1026. *Matricara ambigua* (Ledeb.) Kryl. Leaf, ray and disk flowers.



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1006 1007 1008 1009 1010 1011 1012 1013
1014 1015 1016 1017 1018 1019 1020
1021 1022 1023 1024 1025 1026

PLATE XLIV

Scale in millimeters.

FIG.
1027. *Artemisia darcunculus* L. Leaf, head and marginal flower.
1028. *Artemisia canadensis* Michx. Lower leaf, head and marginal flower.
1029. *Artemisia borealis* Pall. Lower leaf, head and disk flower.
1030. *Artemisia frigida* Willd. Head, achene and leaf.
1031. *Artemisia glomerata* Ledeb. Flower, phyllary and leaf.
1032. *Artemisia senjavinensis* Bess. Flower, phyllary and leaf.
1033. *Artemisia globularia* Cham. Head, leaf and flower.
1034. *Artemisia arctica* Less. Flower, phyllary and leaf.
1035. *Artemisia macrobotrys* Ledeb. Flower and leaf.
1036. *Artemisia trifurcata*.var. *heterophylla* (Bess.) Kudo. Phyllary and leaf.
1037. *Artemisia alaskana* Rydb. Phyllary, flower and leaf.
1038. *Artemisia kruhsiana* Bess. Head and leaf.
1039. *Artemisia unalaskensis* Rydb. Flower and leaf.
1040. *Artemisia tilesii elatior* T. & G. Leaf and flower.
1041. *Tanacetum bipinnatum* (L.) Schultz-Bip. Pinna.
1042. *Tanacetum vulgare* L. Pinna.
1043. *Petasites sagittatus* (Banks) Gray. Leaf.
1044. *Petasites frigidus* (L.) Fries. Leaf.
1045. *Petasites hyperboreus* Rydb. Leaf.
1046. *Petasites palmatus* (Ait.) Gray. Leaf.
1047. *Arnica alpina attenuata* (Greene) Mag. Leaf, achene and phyllary.
1048. *Arnica louiseana frigida* (Meyer) Mag. Achene, leaf and phyllary.
1049. *Arnica latifolia* Bong. Leaf and achene.


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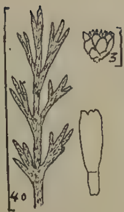
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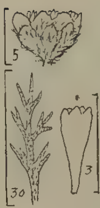
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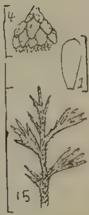
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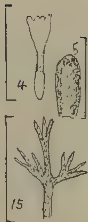
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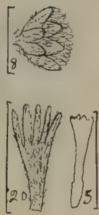
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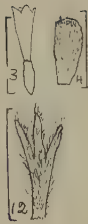
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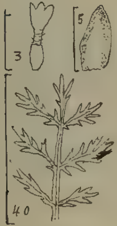
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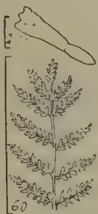
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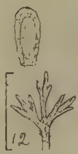
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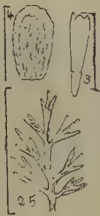
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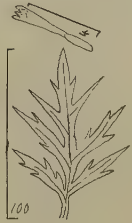
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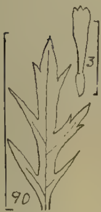
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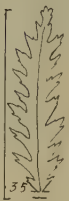
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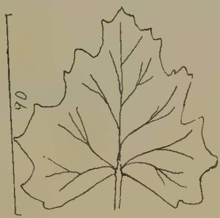
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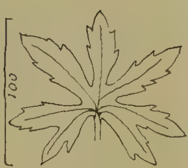
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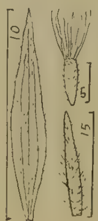
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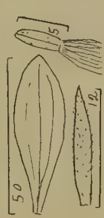
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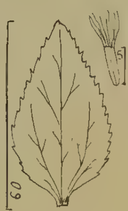
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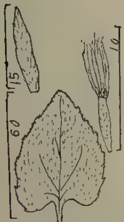
PLATE XLV

Scale in millimeters.

FIG.

1050. *Arnica cordifolia* Hook. Phyllary, leaf and achene.
1051. *Arnica chamissonis* Less. Leaf and flower.
1052. *Arnica amplexicaulis* Nutt. Leaf, achene and phyllary.
1053. *Arnica lessingii* (T. & G.) Greene. Leaf and flower.
1054. *Arnica unalaskensis* Less. Leaf and flower.
1055. *Cacalia auriculata* DC. Leaf, head and flower.
1056. *Senecio congestus* var. *palustris* (L.) Fern. Leaf and achene.
1057. *Senecio atropurpureus frigidus* (Rich.) Hult. Leaf and achene.
1058. *Senecio fuscatus* (Jord. & Fourr.) Hayak. Leaf and flower.
1059. *Senecio yukonensis* Porsild. Leaf, phyllary and flower.
1060. *Senecio hyperborealis* Greenm. Leaf and achene.
1061. *Senecio resedifolius* Less. Leaf and achene.
1062. *Senecio conterminus* Greene. Leaves and achene.
1063. *Senecio indecorus* Greene. Leaves and achene.
1064. *Senecio pauperculus* Michx. Leaves and achene.
1065. *Senecio palmatus* (Pall.) Ledeb. Leaf.
1066. *Senecio lugens* Rich. Leaf and achene.
1067. *Senecio triangularis* Hook. Leaf and flower.
1068. *Senecio pseudo-arnica* Lessing. Leaf and flower.
1069. *Saussurea americana* D. C. Eat. Leaf and achene.
1070. *Saussurea angustifolia* (Willd.) DC. Leaves and achene.
1071. *Saussurea nuda* Ledeb. Leaf and flower.
1072. *Saussurea vicida* var. *yukonensis* (Porsild) Hult. Leaf and flower.
1073. *Cirsium foliosum* (Hook.) DC. Leaf.
1074. *Cirsium kamtschaticum* Ledeb.



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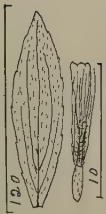

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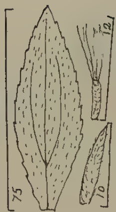

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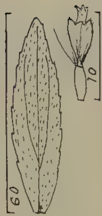

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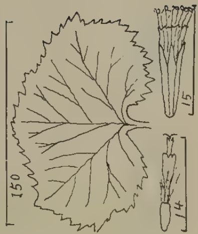

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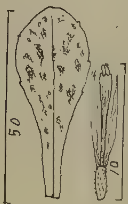

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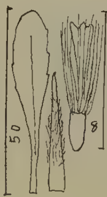

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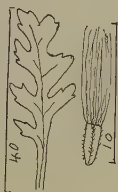

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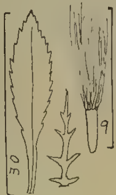

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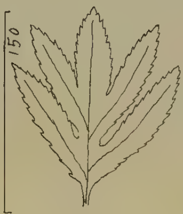

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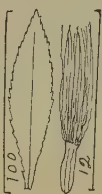

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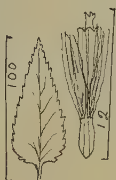

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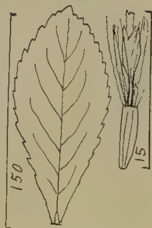

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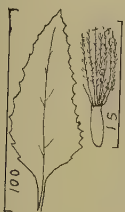

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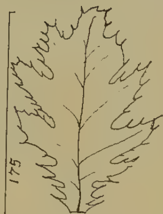

1074

IOWA ASCOMYCETES I. THE XYLARIACEAE [1]

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Iowa Agricultural Experiment Station

Received October 19, 1951

The *Ascomycetes,* because of their number and diversity, comprise a group of fungi that have great mycologic as well as economic interest. They are the largest class of fungi, containing such different morphological representatives as the simple unicellular yeasts and the highly complicated molds. Their parasitism is just as varied: from the obligate parasites such as the powdery mildews to the saprobic red bread mold, *Neurospora.* Their one unifying structure is the ascus, a sac-like cell in which occurs the nuclear fusion culminating sexual reproduction, followed immediately by reduction and the formation of the ascospores, usually eight in number. From this great complexity, the *Xylariaceae* have been chosen as the starting point for cataloguing the members of this class of fungi occurring in Iowa.

The *Xylariaceae,* because of their large and prominent stromata and black perithecia, are among the most conspicuous of our common *Ascomycetes.* They are pre-eminently wood inhabiting, and primarily saprobic, although a few of them have been described as parasites on roots and stems of trees. Thus, *Nummularia discreta* (Schw.) Tul. has been studied as the cause of blister canker of apple [Anderson (1, 2), Cooper (5), Gloyer (8), Rose (16)]; *Hypoxylon pruinatum* (Klot.) Cke. causes of canker of poplar, particularly on fire-damaged areas [Povah (15)], and *Xylaria hypoxylon* (L.) Grev. is found associated with a black root rot of apple [Wolf and Cromwell (20), Fromme and Thomas (7)]. *Rosellinia caryae* Bonar attacks hickory, causing a canker [Bonar (3)] while other members of this genus are associated with root-rots in Europe and the tropics.

Taxonomically the family is characterized by its stromatic fruit-body and its one-celled inequilaterally ovoid dark spores. The treatment follows that of Miller (10), which includes *Rosellinia* in the *Xylariaceae* rather than the *Sphaeriaceae,* and separates *Nummularia* from *Hypoxylon* on the basis of stromatic structure rather than on spore shape or host relations. Miller has included the genus *Anthostoma* in this family. We prefer to treat it as a member of the *Allantosphaeriaceae* as suggested by Wehmeyer (19). *Ustilina vulgaris* Tul. was included in the genus *Hypoxylon* as suggested by Miller.

[1] Journal Paper No. 2014 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1047.

The early collections of members of this family from Iowa were made by E. W. Holway and are available in the Iowa State College Herbarium, and cited by Ellis and Everhart (6) in *North American Pyrenomycetes.* Later collections by students of Pammel and by the authors have been added from time to time. In addition, through the courtesy of Dr. G. W. Martin the collections from the Herbarium of the State University of Iowa were examined. These latter comprised material of several species not represented in the Iowa State Herbarium that had been collected by Macbride, Shimek, Martin and their students. In all, the following numbers of species were found: Hypoxylon 20, Xylaria 6, Nummularia 3, Daldinia 3, and Rosellinia 2.

Key to the genera and species of Iowa Xylariaceae

A. Stromata resupinate
B. Stromata concave .... 1. NUMMULARIA
C. Ascospores subglobose .... 1. *Nummularia discreta*
CC. Ascospores elongate
D. Ascospores 15–16 x 6–7 microns .... 2. *Nummularia repanda*
DD. Ascospores 10–14 x 4–5 microns .... 3. *Nummularia broomeiana*
BB. Stromata convex
C. Surface of stromata carbonaceous and hairy ...... 2. ROSELLINIA
D. Perithecia large, 1–1.5 mm. in diam. .... 1. *Rosellinia aquila*
DD. Perithecia small, ½–⅓ mm. in diam. .... 2. *Rosellinia pulveracea*
CC. Surface of stromata carbonaceous, not hairy .... 3. HYPOXYLON
D. Stromata effused
E. Surface of stromata papillate from exposed apices of the perithecia
F. Stromata irregular in outline, ascospores 10–15 x 5–7 microns .... 1. *H. serpens*
FF. Stromata usually elliptical in outline, ascospores 5–8 x 3–3.5 microns .... 2. *H. effusum*
EE. Surface of stromata not papillate, perithecia erumpent by ostioles only
F. Surface of stromata reddish .... 3. *H. cinereo–lilacinum*
FF. Surface of stromata gray or black
G. Stromata gray, dotted with black mouths of sunken perithecia .... 4. *H. atropunctatum*
GG. Stromata brown to black over entire surface
H. Stromata thin, hollow below perithecial layer; perithecia globose
I. Stromata extended, many perithecia in each stroma
J. Ascospores large, more than 10 microns
K. Ascospores 28–34 x 9–16 microns 5. *H. ustulatum*
KK. Ascospores 10–14 x 4–5 microns 6. *H. illitum*
JJ. Ascospores smaller, less than 10 microns long
K. Ascospores 7–8 x 3.5–4 microns .. 7. *H. albocinctum*
KK. Ascospores 3.5 x 2 microns ..... 8. *H. exiguum*
II. Stromata restricted, few perithecia in each stroma .... 9. *H. regale*

HH. Stromata thick, not hollow; perithecia laterally compressed
I. Ascospores elongate
J. Ascospores 16–22 x 6–8 microns ....10. *H. mediterraneum*
JJ. Ascospores 10–14 x 3–5 microns ...11. *H. tinctor*
II. Ascospores elliptical, 10–14 x 7–9 microns ....12. *H. nummularium*
DD. Stromata pulvinate, not concentrically zonate
E. Stromata semiglobose to globose
F. Ascospores 6–7 x 3–3.5 microns ....13. *H. howeianum*
FF. Ascospores 11–15 x 5–7 microns ....14. *H. coccineum*
EE. Stromata not reaching semiglobose proportions
F. Spores large, more than 15 microns long
G. Spores navicular ....15. *H. pruinatum*
GG. Spores elongate ....16. *H. mammatum*
FF. Spores small, less than 15 microns long
G. Apices of perithecia not prominent ......17. *H. rubiginosum*
GG. Apices of perithecia prominent
H. Perithecia with annulate depression around each ostiole ....18. *H. truncatum*
HH. Perithecia without annulate depression
I. Ascospores, 12–16 x 5–7 microns ......19. *H. fuscum*
II. Ascospores, 9–11 x 3–5 microns ....20. *H. multiforme*
AA. Stromata erect
B. Stromata lanceolate to clavate .... 4. XYLARIA
C. Stromata unbranched
D. Stromata clavate, fertile throughout .... 1. *Xylaria corniformis*
DD. Stromata lanceolate with sterile tips .... 2. *Xylaria carpophilum*
CC. Stromata branched
D. Branches of stromata thick, 1–2 cm. in diam. .. 3. *Xylaria polymorpha*
DD. Branches of stromata slender, ¼–½ cm. in diam.
E. Stromata tall, 6–12 cm. high
F. Ascospores, 14–21 x 3.5–8.5 microns .... 4. *Xylaria cornu-damae*
FF. Ascospores, 13–17.5 x 5.7 microns .... 5. *Xylaria digitata*
EE. Stromata short, 5–8 cm. high .... 6. *Xylaria hypoxylon*
BB. Stromata subglobose to globose, concentrically zoned .... 5. DALDINIA
C. Stromata sessile
D. Surface dull, perithecia not emerging .... 1. *Daldinia concentrica*
DD. Surface rough from apices of perithecia ...... 2. *Daldinia grandis*
CC. Stromata stalked, surface glossy .... 3. *Daldinia ventricosa*

XYLARIACEAE

Stromata very variable in form and size, mostly free at maturity, but often more or less sunken in the matrix, either erect and then often branched, or horizontal, effused, crustaceous, pulvinate, globose or hemispherical, mostly black or becoming black, of woody, carbonaceous or suberose-carnose consistency. Perithecia peripherical, concentrically arranged. Asci cylindrical, 8-spored. Ascospores one-celled, dark, often inequilateral; young stromata clothed with a conidial layer.

1. NUMMULARIA

Stromata orbicular, cup-shaped or discoid, becoming black, marginate, the margin more or less sterile. Perithecia monostichous, peripherical, immersed. Asci cylindrical, 8-spored. Ascospores uniseriate, subelliptical, one-celled, dark.

1. *Nummularia discreta* (Schw.) Tul. (Figs. 1–4)

Stromata concave, sunken below the bark, definitely orbicular in outline, 3–5 mm. in diameter. Perithecia ovate-cylindrical, sunken in the stroma, reaching the surface by ostiolar necks. Asci cylindrical, short stalked, 160–200 x 12–15 microns with long filiform paraphyses. Ascospores sub-globose, one-celled, black at maturity, 8–14 x 8–14 microns in diameter, uniseriate.

On dead branches of *Amelanchier, Pyrus* and *Sorbus.*
On dead wood: Amana, 1936, G. W. Martin
On *Pyrus malus* L.:
Ledges, Boone, 1912, H. S. Coe
Iowa City: 1922, Macbride; 1923, N. W. Baird; 1930, G. W. Martin; 1930, L. Platte; 1930, L. Platte
Wayne: C. L. Smith
On *Amelanchier canadensis* (L.) Medic.: Ledges, Boone, 1924, J. C. Gilman
On *Pyrus communis* L.: Osage, 1927, W. A. Archer
On *Sorbus aucuparia* L.:
Grinnell, 1939, G. W. Martin
Osage, 1927, W. A. Archer
On *Sorbus* sp.: Des Moines Co., 1927, H. E. Nichols

2. *Nummularia repanda* Fr. (Figs. 5–8)

Stromata concave, sunken below the bark, sub-elliptical in outline, 5–10 mm. in diameter. Perithecia ovate-cylindrical, sunken in the stroma, reaching the surface with ostiolar necks. Asci cylindrical, short-stalked, 110–120 x 8 microns, with long filiform paraphyses. Ascospores narrow ovate, subinequilateral, one-celled, dark brown, 8–12 x 3.5–5 microns, obliquely uniseriate.

On dead branches of *Ulmus.*
On *Ulmus americana* L.:
Ledges, Boone, 1950, J. C. Gilman
Estherville, 1929, G. W. Martin
Iowa City, 1926, G. W. Martin; 1929, G. W. Martin; 1940, G. W. Martin; 1946, G. W. Martin
North Liberty, 1938, M. Creighton

Nummularia repanda Fr. is very like *N. discreta;* the stromata are slightly larger and a little less regular in outline. While attempts have been made to separate them on the characters of the ostiolar protrusion the real difference, aside from host, lies in the size and shape of the ascospore.

3. *Nummularia broomeiana* (B. & C.) Miller.

Stromata irregular in shape, suborbicular, 3–4 cm. in diam. or oblong, 5–8 x 3–4 cm. and 0.5–1 cm. thick; surface somewhat uneven, margin partially free, black. Peritheica elongate, more or less angular from compression, with punctiform ostiola. Asci cylindric, p. sp. 70–75 microns long, with a long stalk. Ascospores navicular to inequilaterially elliptical, one-celled, 10.5 x 4.1–5.1 microns, uniseriate.

On dead wood:

Homestead, 1927, D. B. Creager
Iowa City, 1932, L. W. Miller

On black ash: cinnamon fern bog, 1927, B. Shimek

N. broomeiana is described as a tropical species. Three specimens among the collection from the State University fitted the description of this species and hence were referred to it. The stromata are flatter, not as discoid as the other species of *Nummularia* and their margins are somewhat less regular.

2. ROSELLINIA Ces. and de Not.

Perithecia with lower part more or less sunken in a tomentose subiculum, coriaceous or oftener carbonaceous and brittle, spherical or ovate, black with distinct ostiola. Asci cylindrical, 8-spored. Ascospores elliptical, oblong or fusiform, one-celled, dark.

1. *Rosellinia aquila* Fr. (Figs. 9–12)

Perithecia emerging from a loosely felted, thick purplish brown subiculum which finally may disappear. Perithecia large, 1–1.5 mm. in diameter with an outer thick but brittle carbonaecous wall and an inner coriaceous one. Asci cylindrical with long stipe, p. sp. 100–130 x 8–10 microns, and filiform paraphyses. Ascospores, oblong-cymbiform, one-celled, dark brown, 19–28 x 10–12 microns, uniseriate.

Common on decaying wood:

On *Quercus* sp.:

Ames, 1946, L. H. Tiffany
Decorah, 1885, E. W. Holway
Iowa City, 1929, G. W. Martin

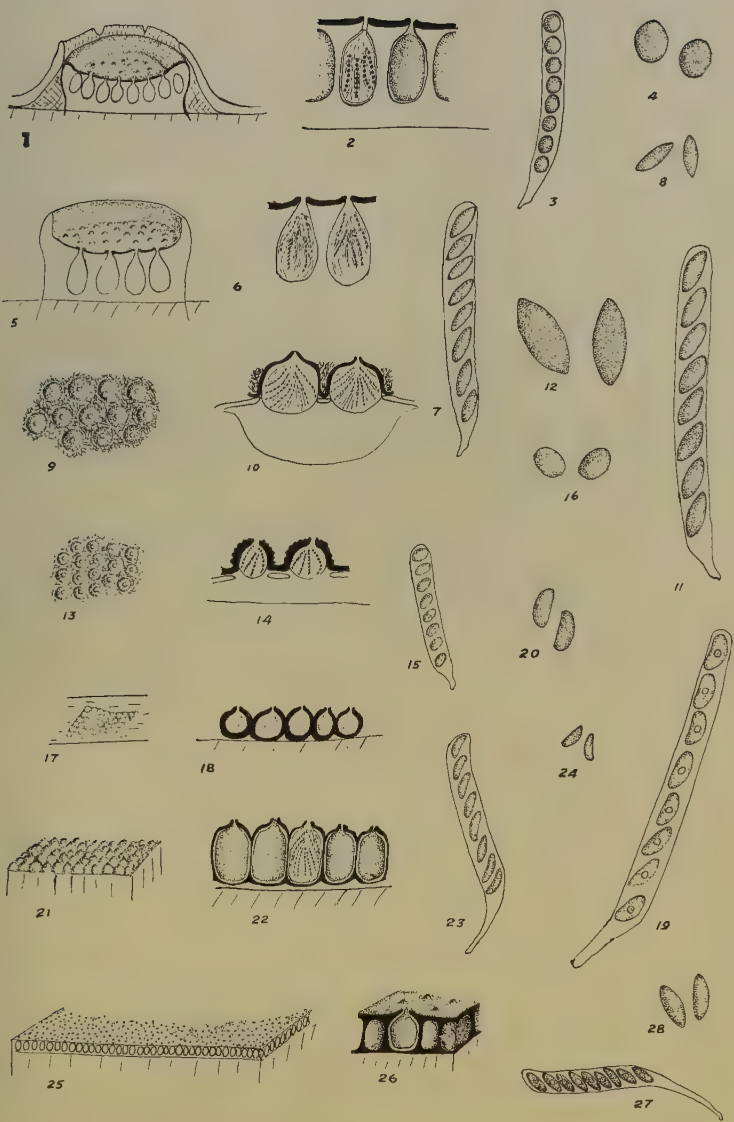
On *Robinia* sp.: Iowa City, 1933, G. W. Martin
On *Ostrya* sp.: Iowa City, 1940, G. W. Martin
On *Platanus* sp.: Iowa, 1937, G. W. Martin

2. *Rosellinia pulveracea* Ehr. (Figs. 13–16)

Perithecia emerging from a loosely felted brown subiculum, densely crowded. Perithecia ⅓ mm. in diameter, with tuberculate walls and papilliform ostioles. Asci cylindrical with long stipe, p. sp. 60–70 x 10–12 microns and filiform paraphyses. Ascospores elliptical, brown, 8–13 x 5–8 microns, uniseriate.

On dead wood:
On *Vitis* sp. Decorah, 1882, E. W. Holway

Figs. 1–4	*Nummularia discreta* 1. Stroma, 2. Perithecia, 3. Ascus, 4. Ascospores
Figs. 5–8	*Nummularia repanda* 5. Stroma, 6. Perithecia, 7. Ascus, 8. Ascospores
Figs. 9–12	*Rosellinia aquila* 9. Stroma, 10. Perithecia, 11. Ascus, 12. Ascospores
Figs. 13–16	*Rosellinia pulveracea* 13. Stroma, 14. Perithecia, 15 Ascus, 16. Ascospores
Figs. 17–20	*Hypoxylon serpens* 17. Stroma, 18. Perithecia, 19. Ascus, 20. Ascospores
Figs. 21–24	*Hypoxylon effusum* 21. Stroma, 22. Perithecia, 23. Ascus, 24. Ascospores
Figs. 25–28	*Hypoxylon cinereo–lilacinum* 25. Stroma, 26. Perithecia, 27. Ascus, 28. Ascospores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Only two species of *Rosellinia* have been collected in Iowa: *R. aquila* Fr. and *R. pulveracea* Ehr. The first seems quite common while the second is known from the state only from the collection of Holway.

3. HYPOXYLON Bulliard.

Stromata of woody-corky consistency, dark brown or black within and without, free from the first or erumpent superficial, sometimes more or less sunken, globose, semiglobose or more or less effused and crustaceous. At first covered by conidial growth, finally bare. Perithecia peripherical, globose, ovate or oblong, sunken in the stromata but generally the upper part more or less projecting, with a papilliform ostiolum. Asci cylindrical, 8-spored. Ascospores, one-celled, elliptical or fusoid, inequilateral, dark, uniseriate.

1. *Hypoxylon serpens* (Pers.) Fr. (Figs. 17–20)

Stromata widely effused, irregular in outline, applanate to pulvinate, with the apices of the perithecia exposed, purplish brown to black. Asci cylindrical, p. sp. 60–85 x 6–8 microns, with long stalk. Ascospores inequilaterally elliptical, one-celled, dark, 8–14 x 4–7 microns, uniseriate.

On decaying wood:

Iowa City, 1936
Ledges State Park, 1951, J. C. Gilman
North Liberty, 1930, G. W. Martin; 1932, L. W. Miller (284); 1933, H. C. Gilbert
Poweshiek County, Moore, 1939, Ruth Gilman
Wellman, 1932, L. W. Miller
Iowa, T. H. Macbride (1414); T. H. Macbride (parasitized by *Amphisphaeria hypoxylon* Ell. & Ev.)

On white oak wood: Iowa City, 1938, G. W. Martin

On *Tilia* sp.: State Quarry, 1930, G. W. Martin

H. serpens (Pers.) Fr. is one of the commoner species on decorticated wood. The almost free perithecia bring it close to Rosellinia species in appearance particularly in older or weathered specimens of the latter. One collection was parasitized by *Amphisphaeria hypoxylon* Ell. and Ev.; the perithecia of the parasite being formed over the surface of the host perithecia.

2. *Hypoxylon effusum* Nits. (Figs. 21–24)

Stromata indefinitely effused, convex, at maturity black, with the apices of the perithecia exposed. Asci cylindrical, p. sp. 50–60 microns, with a long stalk. Ascospores inequilaterally ellipsoid, one-celled, 6–10.5 x 3–5 microns, dark, uniseriate.

On dead wood:

Ames, Squaw Creek, 1936, J. C. Gilman
Iowa City, 1941, M. L. Grunsbein

On elm: Iowa City, 1939, G. W. Martin

3. *Hypoxylon cinereo-lilacinum* Miller. (Figs. 25–28)

Stromata effuse, indeterminate, 3–4 x 1–2 cm., thin, ectostromata purple gray, entostromata black. Perithecia globose to oblong; ostioles slightly emerging from the ectostromata, papillate. Asci cylindric, p. sp. 55–75 microns with a long stalk. Ascospores inequilaterally ellipsoid, one-celled, 8–16 x 3.5–8 microns, dark, uniseriate.

On *Quercus* sp.: Iowa City, 1938, G. W. Martin

On dead wood:

Iowa City, 1923, G. W. Martin; 1923, ———; 1940, Paul Lentz; 1943, G. W. Martin

Iowa: T. H. Macbride

On *Salix* sp.: Bog Creek, 1916, B. Shimek

On *Tilia* sp.: Decorah, 1882, E. W. Holway; 1896, E. W. Holway (170)

On box elder: Iowa City, 1944, G. W. Martin

On *Crataegus* sp.: Milford, 1931, G. W. Martin

On *Ulmus americana* L.: Kalona, 1928, B. Shimek

This species was set up by Miller for the fungus called *H. atropurpureum* by Ellis and Everhart (6) and represented by Ellis, N. A. F. #1180.

4. *Hypoxylon atropunctatum* (Schw.) Cke. (Figs. 29–32)

Stromata effuse, ectostromata white, entostromata dark gray to black. Perithecia globose to flask-shaped, with ostioles protruding through ectostromata as black papillae. Asci, cylindrical, 150–160 x 12–14 microns, with short stalks. Ascospores ellipsoid, one-celled, 21–28 x 14–15 microns, dark, uniseriate.

On dead wood:

California Jct., 1905, B. Shimek
Cou Falls, 1912, J. A. Parish
Homestead, 1927, D. B. Creager
Indian Lookout, 1927, C. W. Emmons
Iowa City, 1926, C. W. Emmons
Johnson Co., 1902, B. Shimek
Monroe Co., A. F. Evers
Wayne, 1893, C. L. Smith (1402)
Iowa, ———

On red oak:

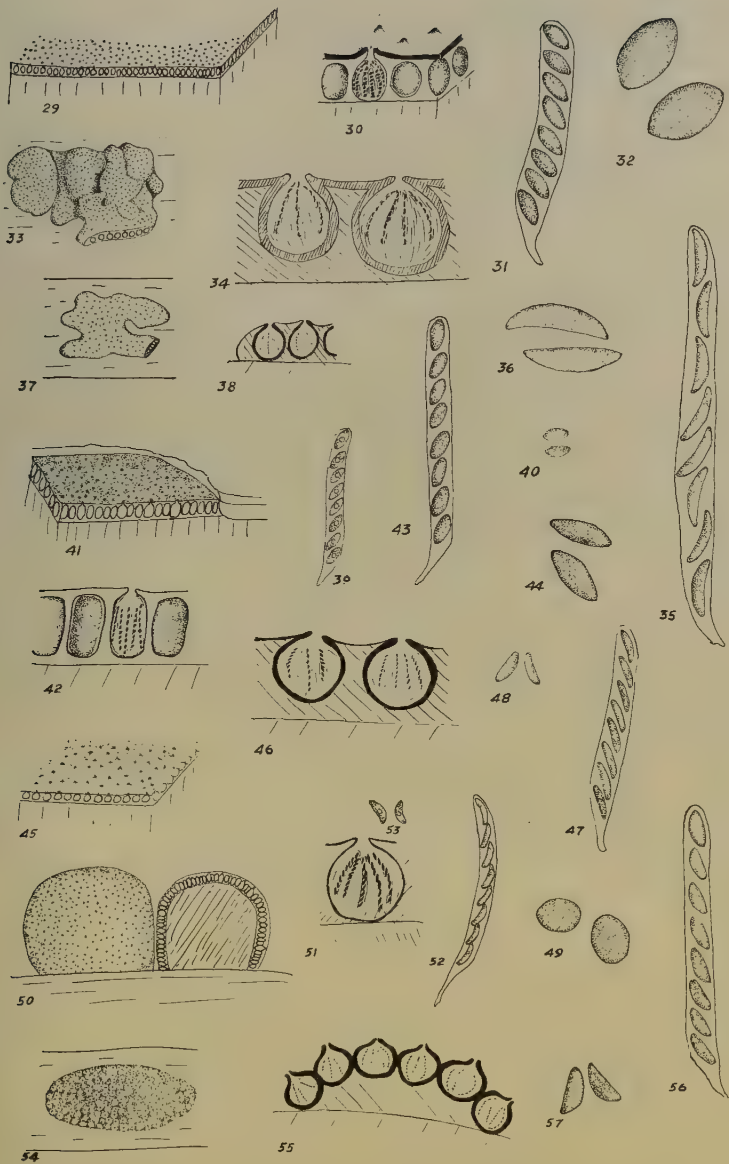
Amana, 1938, G. W. Martin
Cedar Valley, 1933, R. S. Anderson
Cou Falls, 1927, G. W. Martin
Iowa City, 1936, G. W. Martin
Ralston, 1936, B. Shimek

On *Quercus alba*: Palisades, 1933, ———

5. *Hypoxylon ustulatum* Bull. (Figs. 33–36)

Stromata indefinitely extended, undulate, repand to subpulvinate,

Figs. 29–32	*Hypoxylon atropunctatum* 29. Stroma, 30. Perithecia, 31. Ascus, 32. Ascospores
Figs. 33–36	*Hypoxylon ustulatum* 33. Stroma, 34. Perithecia, 35. Ascus, 36. Ascospores
Figs. 37–40	*Hypoxylon albocinctum* 37. Stroma, 38. Perithecia, 39. Ascus, 40. Ascospores
Figs. 41–44	*Hypoxylon mediterraneum* 41. Stroma, 42. Perithecia, 43. Ascus, 44. Ascospores
Figs. 45–48	*Hypoxylon illitum* 45. Stroma, 46. Perithecia, 47. Ascus, 48. Ascospores
Fig. 49	*Hypoxylon nummularium* 49. Ascospores
Figs. 50–53	*Hypoxylon howeanum* 50. Stromata, 51. Perithecium, 52. Ascus, 53. Ascospores
Figs. 54–57	*Hypoxylon coccineum* 54. Stroma, 55. Perithecia, 56. Ascus, 57. Ascospores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1.5 to 3 mm. thick, becoming carbonaceous and black with age. Perithecia very large, globose with papillate ostiolar necks. Asci cylindrical, 190–260 x 10–15 microns, long stalked. Ascospores inequilaterally elliptical to fusoid, one-celled, 28–34 x 7–10 microns, dark, uniseriate.

On dead wood:

Ames, ———, L. H. Pammel
Charles City, 1912, B. Shimek
Decorah, 1882, E. W. Holway
Iowa City, 1935, G. W. Martin
Ledges State Park, 1927, J. C. Gilman
Midriver, 1924, G. W. Martin
Muscatine Co., 1902, B. Shimek
Turkey Creek, 1935, ———
Iowa, 1896, Macbride
———, ———, Macbride

H. ustulatum had long been known in America under the name *Ustulina vulgaris* Tul. Miller (11) returned it to Hypoxylon and indicated its relationship to the species immediately following in this paper, i.e., *H. illitum*, *H. albocinctum*, *H. exiguum* and *H. regale*. In these species the perithecia remain completely sunken emerging by their ostioles. They are readily separable by the extent of the stroma and the various spore sizes.

6. *Hypoxylon illitum* (Schw.) Sacc. (Figs. 45–48)

Stromata indefinitely extended, undulate repand to subpulvinate, at first olive-green, but finally black. Perithecia large, globose, with papillate ostiolar necks. Asci cylindrical, p. sp. 70–95 microns, with long stalk. Ascospores fusoid, navicular, one-celled, 10.5–14 x 3.5–7 microns, dark, uniseriate.

On dead wood:

Homestead, 1925, G. W. Martin
Iowa City, 1896, C. L. Smith; 1936, ———
Milford, 1934, E. T. Reese
Turkey Creek, 1932, L. W. Miller

On rotted oak in greenhouse: Iowa City, 1942, G. W. Martin

7. *Hypoxylon albocinctum* E & E. (Figs. 37–40)

Stromata, mostly orbicular, undulate to repand, thin (1 mm. thick) light cinereous at first, becoming purplish black. Perithecia globose with papillate ostiolar necks. Asci cylindrical, 80–100 x 5–6 microns, with long stalk. Ascospores narrowly elliptical, subacute, one-celled, 7–10.5 x 3.5–4 microns, dark, uniseriate.

On dead wood:

Cedar Falls, J. A. Parish
Decorah, 1928, ———
McGregor, 1921, B. Shimek
North Liberty, 1935, G. W. Martin

On *Fraxinus* sp., 1947, G. W. Martin
On *Ostrya* sp., 1943, G. W. Martin
On *Ostrya virginiana* (Mill.) K. Koch.: Postville, 1926, B. Shimek
On *Ulmus* sp., Iowa City, 1942, G. W. Martin

8. *Hypoxylon exiguum* Cke. (Figs. 113–116)

Stromata small, irregularly pulvinate, black. Perithecia globose, numerous, with papillate ostiolar necks. Asci cylindrical with long stalk. Ascospores elliptical, one-celled, 3.5–5 x 1.5–2 microns, dark, uniseriate.
On dead *Salix* sp.: Southwest Okoboji, 1936, T. W. Brasfield

9. *Hypoxylon regale* Morg. (Figs. 109–112)

Stromata small, orbicular, black, consisting of a few perithecia. Perithecia globose, large, with papillate ostiolar necks. Asci cylindrical, long stalked. Ascospores unequilaterally fusoid, one-celled, 21–26 x 12–14 microns, dark, uniseriate.
On *Fraxinus* sp.: Okoboji, ———, T. H. Macbride

10. *Hypoxylon mediterraneum* (De Not.) Miller. (Figs. 41–44)

Stromata, broadly effused, black, punctulate, with the slightly prominent ostiola. Perithecia large ovate, closely packed. Asci cylindrical, short stalked, 100–115 x 10 microns. Ascospores broadly elliptic, one-celled, 14–20 x 6–10.5 microns, dark, uniseriate.
On dead wood:
Center Lake, Dickinson Co., 1901, B. Shimek
Iowa City, 1902, ———; 1911, T. H. Macbride; 1933, G. W. Martin; 1935, G. W. Martin; 1936, G. W. Martin; 1939, G. W. Martin
Tiffin, 1927, C. W. Emmons
Iowa, 1908, T. H. Macbride; ———, T. H. Macbride
On *Acer nigrum* Michx. f.: Ames, 1913, J. P. Anderson
On *Acer* sp.: Iowa City, 1909, T. H. Macbride
On *Betula lutea* Michx. f.: Iowa City, 1925, G. W. Martin
On *Ostrya* sp.: Iowa City, 1929, G. W. Martin
On red oak:
Iowa City, 1937, G. W. Martin; 1942, G. W. Martin
Wayne, ———, C. L. Smith
On white oak: Iowa City, 1933, G. W. Martin; 1934, ———; 1938, G. W. Martin
On *Quercus* sp.:
Ames, 1899, H. H. Hume
Decorah, 1882, E. W. Holway
Iowa City, 1936, G. W. Martin; 1939, G. W. Martin
On *Tilia* sp.: Traer, 1927, B. Shimek
On *Ulmus* sp.: Cou Falls, 1927, C. W. Emmons

The three species, *H. mediterraneum, H. tinctor* and *H. nummularium* have been variously referred to the genera *Hypoxylon* and *Num-*

Figs. 58–62	*Hypoxylon pruinatum* 58. Stroma, 59. Perithecia, 60. Perithecium, 61. Ascus, 62. Ascospores
Figs. 63–66	*Hypoxylon mammatum* 63. Stroma, 64. Perithecia, 65. Ascus, 66. Ascospores
Figs. 67–71	*Hypoxylon rubiginosum* 67. Stroma, 68. Perithecia, 69. Perithecium, 70. Ascus, 71. Ascospores
Figs. 72–75	*Hypoxylon truncatum* 72. Stroma, 73. Perithecia, 74. Ascus, 75. Ascospores
Figs. 76–80	*Hypoxylon fuscum* 76. Stroma, 77. Perithecia, 78. Perithecium, 79. Ascus, 80. Ascospores
Figs. 81–84	*Hypoxylon multiforme* 81. Stroma, 82. Perithecia, 83. Ascus, 84. Ascospores


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mularia by the students of the Xylariaceae prior to Miller. Their submerged stromata simulate the stroma of *Nummularia discreta* but the structure of the perithecia and their relations to the stromata indicate a closer relationship to the genus Hypoxylon. The species are separable on spore characters.

11. *Hypoxylon tinctor* (Berk.) Cke. (Figs. 125–128)

Stromata effused, dull black, very hard, 1 mm. thick, 5–20 cm. long and 2–5 cm. wide, margin thin and sterile, papillose from protruded mouths of the perithecia. Perithecia crowded, elongate. Asci cylindric, p. sp. 90–100 x 7–8 microns, with filiform paraphyses. Ascospores, oblong navicular, inequilateral, one-celled, 15 x 6 microns, dark, uniseriate.
On dead wood: Iowa: ———, B. Shimek (M. 6118)

12. *Hypoxylon nummularium* (Bull.) ex Fr. (Fig. 49)

Stromata widely effused applanate, black at maturity, carbonaceous. Perithecia large, ovate, closely packed, with papillate ostiolar necks. Asci cylindrical with short stalk, 100–125 x 10–12 microns. Ascospores elliptical to subglobose with rounded ends, one-celled, 10–14 x 7–10 microns, dark, uniseriate.
On dead wood:
Iowa City, 1939, G. W. Martin
Turkey Creek, 1907, J. A. Parish
Iowa, ———, B. Shimek
Iowa, ———, ———
On box elder: Postville, 1929, B. Shimek
On oak:
Iowa City, 1929, G. W. Martin
Iowa, ———, T. H. Macbride
On *Ulmus* sp.: Iowa City, 1907, ———

12a. *Hypoxylon nummularium* var. *macrosporum* n. var.

Differs from *H. nummularium* by its larger spores, 14–16 x 10–14 microns.
On white oak: Iowa City, 1933, G. W. Martin

13. *Hypoxylon howeianum* Pk. (Figs. 50–53)

Stromata globose to hemispherical, 3–12 mm. in diameter and 3–8 mm. high. Ectostromata brick red, at first, becoming black with age. Perithecia small, ovate, with slightly protruding ostiolar necks. Asci cylindrical, p. sp. 50–60 microns. Ascospores ellipsoid, one-celled, 6–9 x 3.5–4 microns, dark, uniseriate.
On dead wood:
Wayne, 1893, C. L. Smith
———, ———, T. H. Macbride
On dead *Ostrya* sp.: Decorah, 1882, E. W. Holway
On dead *Quercus* sp.: Decorah, ———, E. W. Holway (6)
On dead *Tilia* sp.: North Liberty, 1946, G. W. Martin

14. *Hypoxylon coccineum* Bull. (Figs. 54–57)

Stromata globose to hemispherical, distinctly roughened by prominent perithecia, brick-red at first, becoming black with age. Perithecia globose to oblong with short ostiolar necks. Asci cylindrical, p. sp. 70–85 microns, with long stalk. Ascospores inequilaterally ellipsoid, one-celled, 10.5 x 4 microns, dark, uniseriate.

On dead wood:

Decorah, 1903, B. Shimek
Iowa, 1892, ———

15. *Hypoxylon pruinatum* Klotszch (Figs. 58–62)

Stromata orbicular, black, with white pruinose coat, smooth except for acutely papillose black ostiola. Perithecia large, 10–30 in each stroma. Asci cylindrical with short stalk. Ascospores ellipsoid, one-celled, 21–28 x 8–14 microns, dark, uniseriate.

On dead *Populus* sp.:

Boone, Ledges, 1924, J. C. Gilman
Decorah, 1882, E. W. Holway (6)

16. *Hypoxylon mammatum* (Wigg.) Miller (Figs. 63–66)

Stromata, orbicular, 3–5 mm. in diameter, papillose from prominent ostiola. Perithecia large, 4–15 in a stroma. Asci cylindrical, 110–120 x 12 microns. Ascospores oblong-elliptical, one-celled, 15–21 x 7–8 microns, dark, uniseriate.

On *Carpinus* sp.: Decorah, 1882, E. W. Holway [as *H. morsei* B. & C. (6)]

On *Salix longifolia* Muhl.: Iowa City, 1934, G. W. Martin (1405)

17. *Hypoxylon rubiginosum* (Pers. Fr.) (Figs. 67–71)

Stromata pulvinate to effused, indefinite in extent, continuous for several centimeters on decorticated wood, bright brick-red when young becoming black with age. Perithecia globose, and exposed at their apices. Asci cylindrical, p. sp. 70–80 x 10–12 microns, with long stalk. Ascospores, inequilaterally elliptical, one-celled, 8–14 x 3.5–7 microns, uniseriate.

On dead wood:

Cedar Falls, 1907, J. A. Parish
Cou Falls, 1907, T. H. Macbride
Decorah, 1882, E. W. Holway [as *H. piceum* (6)]
Homestead, 1924, G. W. Martin
Iowa City, 1924, G. W. Martin
Iowa City, Mercus Farm, 1946, P. P. Gardner
Johnson Co., 1894, B. Shimek
Johnson Co., Mills Creek, 1933, R. S. Anderson
Milford, 1928, F. Howard
Muscatine Co., 1893, C. L. Smith
North Liberty, 1926, G. W. Martin; 1934, G. W. Martin

Figs. 85–88 *Xylaria corniformis*
85. Stromata, 86. Perithecia, 87. Ascus, 88. Ascospores

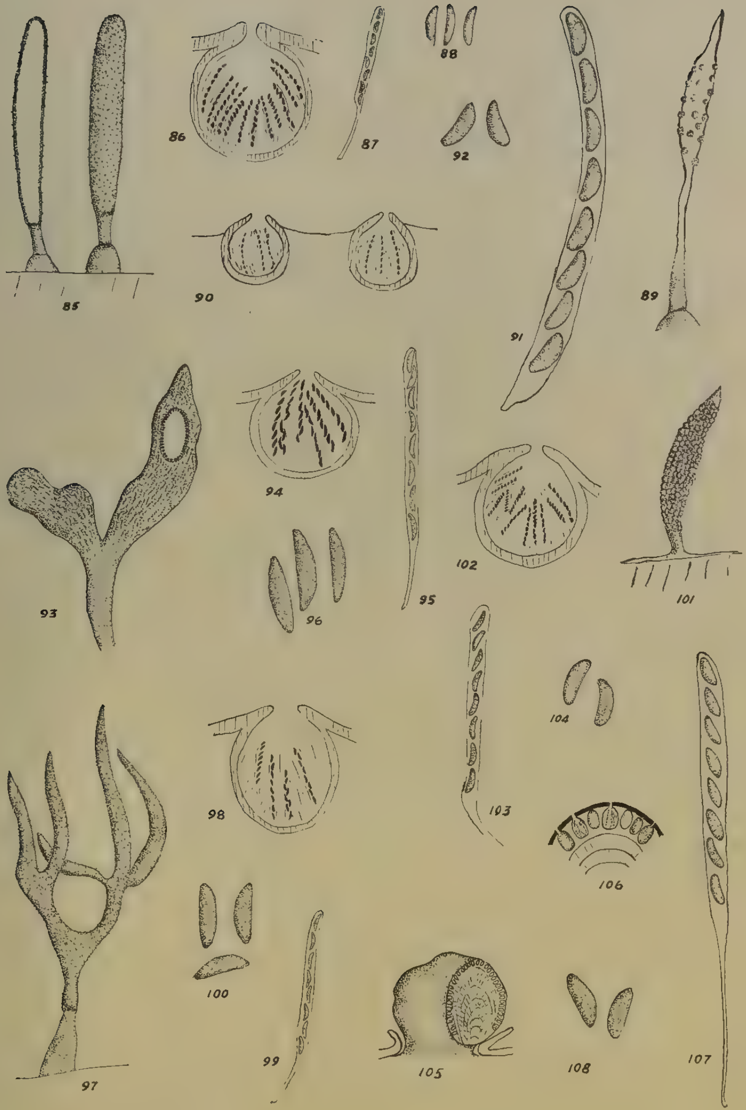
Figs. 89–92 *Xylaria carpophila*
89. Stroma, 90. Perithecia, 91. Ascus, 92. Ascospores

Figs. 93–96 *Xylaria polymorpha*
93. Stroma, 94. Perithecium, 95. Ascus, 96. Ascospores

Figs. 97–100 *Xylaria cornu-damae*
97. Stroma, 98. Perithecium, 99. Ascus, 100. Ascospores

Figs. 101–104 *Xylaria hypoxylon*
101. Stroma, 102. Perithecium, 103. Ascus, 104. Ascospores

Figs. 105–108 *Daldinia concentrica*
105. Stroma, 106. Perithecia, 107. Ascus, 108. Ascospores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Okoboji, 1910, T. H. Macbride (1409)
Wellman, 1932, L. W. Miller
Winneshiek Co., 1903, B. Shimek

On basswood: Milford, 1916, B. Shimek

On *Corylus* sp.:
Decorah, 1882, E. W. Holway
Indian Lookout, 1927, C. W. Emmons
Iowa City, C. L. Smith

On *Crataegus* sp.:
Iowa City, 1925, G. W. Martin (1422)
Turkey Creek, 1927, D. B. Creager
West Liberty, 1928, D. B. Creager

On hickory: Iowa City, 1939, G. W. Martin

On honey locust: Iowa, 1898, T. H. Macbride (1408)

On *Prunus virginiana* L.: Ames, 1950, H. Kobel

On *Quercus* sp.:
Decorah, 1882, E. W. Holway
Fort Dodge, 1928, B. Shimek
Tiffin, 1927, G. W. Martin
Iowa, ———, J. A. Parish (*Quercus alba*)

On *Quercus alba* L.: Iowa, 1923, B. Shimek

On *Salix* sp.: Bog Creek, 1916, B. Shimek

On *Salix alba* L.: Landwood, 1928, B. Shimek

On *Ulmus* sp.: Iowa City, 1925, G. W. Martin (1421)

On *Tilia*: Okoboji, Emerson's Bay, 1925, G. W. Martin

18. *Hypoxylon truncatum* (Schw. ex Fr.) Miller. (Figs. 72–75)

Stromata hemispherical when growing on bark, indeterminately effused when on decorticated wood, tobacco-brown when young, black at maturity. Perithecia large, globose, with an annulate depression around the ostiolar necks. Asci cylindrical, 60–70 microns in length, with long stalk. Ascospores inequilaterally elliptical, 7–10.5 x 3.5–7 microns, dark, uniseriate.

On *Quercus alba* L.: Homestead, 1927, B. Shimek

On dead wood:
Iowa City, Cou Falls, 1912, J. A. Parish
Cou Falls, 1927, C. W. Emmons; 1896, C. L. Smith; 1926, G. W. Martin; 1937, R. Armacost; 1939, G. W. Martin
North Liberty, 1927, T. W. Brasfield; 1927, D. B. Creager
Johnson Co., T. H. Macbride (1410)
Monroe Co., A. F. Ewers
Steamboat Rock, Hardin Co., 1903, B. Shimek
Tunica, 1936, B. Shimek
Turkey Creek, 1907, J. A. Parish; 1932, L. W. Miller; 1935, H. H. La Fuze
Wayne Co., C. L. Smith

On oak:

Cou Falls, 1927, C. W. Emmons
Iowa City, 1939, G. W. Martin
Midriver, 1924, H. Nicholson

On *Ulmus americana* L.: Clayton Co., 1922, B. Shimek

Shear (17) has treated this material as two species, *H. annulatum* and *H. marginatum* but a study of the Iowa material indicated that there is little distinction between the stromata on the differing habitats; hence they are treated as a single species, *H. truncatum*, following the usage of Miller (12).

19. *Hypoxylon fuscum* Fr. (Figs. 76–80)

Stromata hemispherical, generally 1–3 mm. in diameter, dark purplish-red becoming black, and papillate from apices of protruding perithecia. Perithecia subglobose with minute mammiliform ostiola. Asci cylindrical, p. sp. 80–90 x 7–8 microns, with long stalk. Ascospores inequilaterally elliptical, one-celled, 10.5–14 x 3.5–7 microns, dark, uniseriate.

On dead wood: Homestead, 1924, F. S. Paine
On *Acer* sp.: Iowa, 1894, T. H. Macbride
On *Carya cordiformis* (Wang.) K. Koch: McGregor, 1928, ———
On *Ostrya* sp.: Iowa City, 1927, G. W. Martin
On *Tilia* sp.: Okoboji, 1926, M. L. Lohman

20. *Hypoxylon multiforme* Fr. (Figs. 81–84)

Stromata erumpent and marginal by the ruptured bark, oblong to elliptical 1–15 cm. long by 0.5–0.75 cm. wide or confluent, dull red at first, finally black. Perithecia large, globose, prominent with papilliform ostiola. Asci cylindrical, p. sp. 70–90 x 6 microns, with long stalk. Ascospores inequilaterally elliptical, one-celled, 7–10.5 x 3.5–4 microns, dark, uniseriate.

On dead wood:

Iowa City, 1893, B. Shimek, (1396); 1925, A. W. Martin
Midriver, 1924, K. A. Gilmore

On *Betula alba* L.: Winneshiek Co., 1926, B. Shimek

On *Quercus* sp.:

Muscatine Co., 1893, C. L. Smith
Wayne Co., ———, C. L. Smith (1397)
Iowa, ———, J. A. Parish

4. XYLARIA Hill

Stromata erect or ascending, cylindrical clavate or filiform, simple or branched, of a corky, leathery or fleshy consistency, black outside, mostly white within. Perithecia sunken in the stromata, often emerging, globose or ovate with a papilliform ostiolum. Asci cylindrical, 8-spored. Ascospores elliptical or fusoid, mostly inequilateral, one-celled, dark.

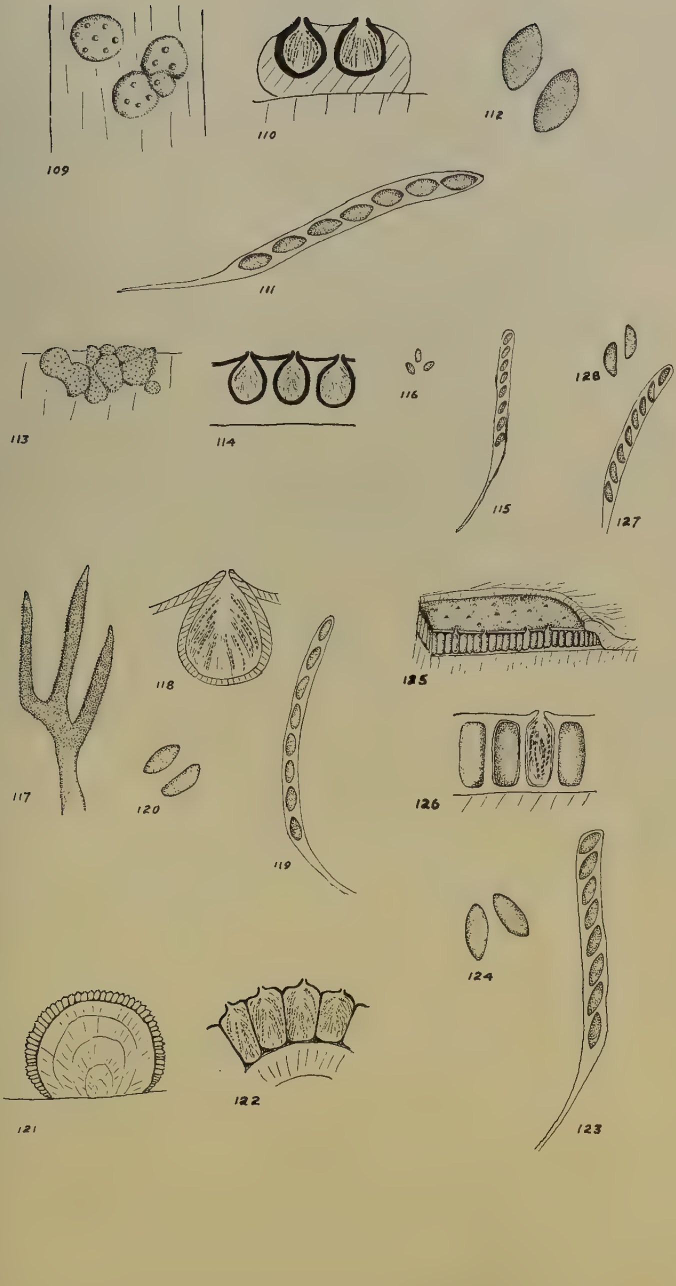
Figs. 109–112 *Hypoxylon regale*
109. Stromata, 110. Perithecia, 111. Ascus, 112. Ascospores

Figs. 113–116 *Hypoxylon exiguum*
113. Stroma, 114. Perithecia, 115. Ascus, 116. Ascospores

Figs. 117–120 *Xylaria digitata*
117. Stroma, 118. Perithecium, 119. Ascus, 120. Ascospores

Figs. 121–124 *Daldinia grandis*
121. Stroma, 122. Perithecia, 123. Ascus, 124. Ascospores

Figs. 125–128 *Hypoxylon tinctor*
125. Stroma, 126. Perithecia, 127. Ascus, 128. Ascospores



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1. *Xylaria corniformis* Fr. (Figs. 85–88)

Stromata scattered or subgregarious, simple, clavate, obtuse at the apex, 3–5 cm. high and 4–5 mm. thick, becoming brownish black, often minutely areolate-rimose, surface roughened by papilliform ostiola. Stipe short, black, arising from a spongy base. Perithecia globose. Asci cylindrical, p. sp. 60–70 x 5–6 microns, long stalked. Ascospores inequilaterally elliptical, obtuse at the ends, one-celled, 7–13 x 3.5–7 microns, dark, uniseriate.

On dead wood:

Cou Falls, 1909, T. H. Macbride
Decorah, 1882, E. H. Holway
Hesper, 1903, B. Shimek
Iowa City, 1924, G. W. Martin; ———, T. H. Macbride
North Liberty, 1941, G. W. Martin
Turkey Creek, 1935, G. W. Martin

2. *Xylaria carpophila* (Pers.) Fr. (Figs. 89–92)

Stromata erect, slender, lanceolate, often curved, simple or cleft at the apex, dark, more or less wooly tomentose at the base, with perithecia scattered and often sparse. Perithecia globose with papilliform ostiole. Asci cylindrical, long stalked, p. sp. 80 x 6 microns. Ascospores obtuse-fusoid, inequilateral, one-celled, 12–16 x 5 microns, dark, uniseriate.

On decaying *Crataegus* fruits and leaves:

Elm Crest, 1929, A. P. Kelly
West Okoboji, 1927, F. L. Howard
———, ———, ———

The *Xylaria* species on Crataegus was described by Tulasne (18) as distinct from *Xylaria carpophila* under the name *Xylaria oxyacanthae*. The identity of the two was pointed out by Lloyd (9).

3. *Xylaria polymorpha* (Pers.) Grev. (Figs. 93–96)

Stromata solitary or 2–6 or more caespitose-connected at base, erect, subattenuated above and below, obtuse or irregular in shape, thick, brown becoming black, not shining, very variable in size. Perithecia crowded, large, ovate or globose, with papilliform ostiola. Asci cylindrical, p. sp. 140–180 x 8–18 microns, long stalked. Ascospores subinequilaterally elliptical or fusoid, subacute at the ends, one-celled, 22–28 x 6–9 microns, uniseriate.

On dead wood:

Ames, 1899, ———; 1900, ———; 1902, ———
Bixby State Park, Clayton Co., 1928, B. Shimek
Decorah, 1882, ———
Arnold's Park, 1912, B. Shimek
Hardin Co., 1902, B. Shimek
Iowa City, 1907, Macbride; 1910, J. A. Parish; 1939, C. Brian; 1936, G. W. Martin; 1938, G. W. Martin
Lyon Co., 1902, B. Shimek

Muscatine Co., 1902, B. Shimek
Sioux City, 1902, B. Shimek

4. *Xylaria cornu-damae* (Schw.) Berk. (Figs. 97–100)

Stromata erect, 2–10 cm. high, usually furcately or more times divided, black at maturity, heads fertile except for a short sterile tip and contracted below into a slender stipe arising from a purplish-black tomentum. Perithecia prominent, globose, black with short papilliform ostiola. Asci cylindrical, p. sp. 100–110 x 5 microns, with long stalk. Ascospores fusoid, one-celled, 14–21 x 3.5–8.5 microns, dark, uniseriate.

On dead wood:

Decorah, 1882, E. W. Holway
Dubuque Co., 1897, T. H. Macbride
Winneshiek Co., 1903, B. Shimek

5. *Xylaria digitata* (L.) Grev. (Figs. 117–120)

Stromata erect, tufted, connate below, thick, dark-brown, 2-3-dichotomously branched. Perithecia numerous, crowded, slightly prominent, with papilliform ostiola. Asci cylindrical, long stalked, p. sp. 100–120 x 7 microns, 8-spored. Ascospores navicular-fusoid, inequilateral, one-celled, 13–17 x 5–7 microns, dark, uniseriate.

On dead wood:

Dubuque, 1928, F. Howard
North Liberty, 1926, G. W. Martin and G. Sheak

On fallen oak: Iowa, 1947, G. W. Martin

6. *Xylaria hypoxylon* (Linn.) Grev. (Figs. 101–104)

Stromata erect, simple or variously branched, black, wooly-tomentose at base, 5–8 cm. high, lanceolate with a sterile tip; stem short, distinct from the fertile head which is covered by the prominent ovate, crowded perithecia with papillate ostiola. Asci cylindrical, p. sp. 75–80 x 7–8 microns, long stalked. Ascospores inequilaterally fusoid, obtuse at each end, one-celled, 7–11 x 3.5–6 microns, dark, uniseriate.

On dead wood:

Ames, 1921, J. C. Gilman
Decorah, 1882, E. W. Holway
Cou Falls, 1927, Edna Huber
Iowa City, 1923, G. W. Martin; 1928, G. W. Martin
Muscatine Co., 1899, T. H. Macbride
Moscow, 1923, H. Monosmith
North Liberty, 1926, ———; 1930, G. W. Martin
Pine Hollow, 1929, B. Shimek
Riverside, 1933, G. W. Martin
Tama, 1928, ———
Tiffin, 1927, G. W. Martin
Johnson Co., ———, T. H. Macbride

5. DALDINIA Ces. and de Not.

Stromata superficial, subglobose, external layer carbonaceous, becoming black, fibrous within and concentrically zoned. Perithecia peripherical, immersed in the stromata. Asci cylindrical, 8-spored, with long stalks. Ascospores ovoid to oblong, one-celled, dark.

1. *Daldinia concentrica* (Bolt.) Ces. & de N. (Figs. 105–108)

Stromata, hemispherical to globose, sessile or substipitate, single or confluent, 1–10 x 1–7 x 1–7 cm., rubiginous when young, becoming black, usually dull, concentrically zonate. Perithecia, claviform with punctiform ostiola. Ascospores inequilaterally ellipsoid, one-celled, 12–15 x 5–5.5 microns, dark, uniseriate.

On dead wood:

Ames, 1899, L. H. Pammel
Coon Grove, Winnebago Co., 1912, B. Shimek
Decorah, 1882, E. W. Holway
Iowa City, 1908, T. H. Macbride; 1915, Boot; 1923, G. W. Martin; 1927, B. Shimek; 1937, G. W. Martin; 1942, G. W. Martin
Little Sioux, 1912, Giddings
Macbride Park, 1936, E. F. Pierson
Nichols, 1939, G. W. Martin
West Okoboji, Miller's Bay, 1926, M. L. Lohman
Winnebago Co., 1902, B. Shimek

On *Acer* sp.: Iowa City, 1915, B. Shimek
On *Ulmus* sp.: Spirit Lake, 1913, B. Shimek
On *Fraxinus* sp.: Magill, 1922, B. Shimek
On *Carpinus* sp.: Pine Hollow, 1921, B. Shimek

2. *Daldinia grandis* Child. (Figs. 121–124)

Stromata sessile, hemispherical, carbonaceous, woody, 1.2–14 x 1.5–7.5 x 1–5 cm. Surface dull black, extremely brittle with apices of perithecia prominent. Interior conspicuously zonate, densely fibrous. Perithecia large pyriform to subclaviform, large. Ascospores inequilaterally ellipsoid, one-celled 17.5–19 x 5–7 microns, dark, uniseriate.

On dead wood:

Iowa
W. Lake Okoboji, 1915, ———

In treating the Iowa species of *Daldinia,* the work of Child (4) has been followed.

3. *Daldinia vernicosa* (Schw.) Ces. & de Not.

Stromata subturbinate, contracted below into a distinct rugose stipe with zones externally visible; single or confluent, fragile 0.6–3.5 x 0.5–2.5 x 0.8–2.5 cm. Surface hard, brittle laccate, black interior with zonation conspicuous from the lighter gray white, collapsing zones alternating with dark to black persistent zones. Perithecia ovoid oblong with

punctiform ostiola. Ascospores ellipsoid with obtusely rounded ends, one-celled, 10.5 x 7 microns, dark, uniseriate.

On dead wood:

Backbone State Park, 1917, B. Shimek

Bluffton, 1926, G. W. Martin; 1936, G. W. Martin; 1942, G. W. Martin; 1943, G. W. Martin

Iowa City, 1939, G. W. Martin

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FLUCTUATIONS IN BOB-WHITE POPULATIONS, DECATUR COUNTY, IOWA[1]

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The Iowa Cooperative Wildlife Research Unit inaugurated field work on the Eastern Bob-White, *Colinus virginianus virginianus* L., on the 7,713-acre Decatur County Research Area in the fall of 1935. This privately owned area is contained within parts of High Point and Woodland Townships in Decatur County and parts of Clay and Jefferson Townships in Wayne County. The project was initiated to determine the seasonal habitat requirements of the bob-white and to formulate management plans that were compatible with agricultural practices. Also, the investigation was instigated for the purpose of obtaining population data on a long-term basis. Spring and fall population counts were obtained from the fall of 1935 until the fall of 1944 with the exceptions of spring counts for 1938 and 1939. Due to the lack of personnel and World War II, research was curtailed until the spring of 1949 when population investigations were continued.

The topography of the Decatur area is rolling with gentle to steep slopes, which is characteristic of the Kansan and Nebraskan or pre-Kansas drifts left by the last and next-to-the-last glacial invasions. These parent soils were covered later by a layer of loess of the Grundy Series (Brome, 1936).

Originally an oak-hickory forest covered the uplands and elm-ash-walnut forests, the more gentle slopes and creek bottoms. The removal of about 90 per cent of the timber and the cultivation of the land during the last 100 years resulted in extensive sheet and gully erosion. Uncontrolled water runoff eroded much of the humus and loess along with some of the drift from the upland and slopes and deposited some of these materials on the flooded lowlands. About 1930 the periodic flooding of Steele Creek, the main source of drainage on the area, was relieved by dredging and straightening the creek bed (Sanders, 1943).

Land usage, according to total crop acreages, has not changed greatly in the past 15 years. Mangold (1950) compared the land use trends of 1939 (Sanders, 1943) and 1949. Corn and small grains acreages (15 per cent) showed practically no variation. Pastures increased

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from 55 to 62 per cent and hay legumes and grasses from 4 to 9 per cent. No measurement of the recent tendency for larger farms was made. Even though total acreages of various farming practices has not varied greatly, the farms have been enlarged and a certain loss of cover dispersion, so important to quail, has resulted.

FIELD TECHNIQUES

During the fall (October-December) and spring (March-April) of each year the farmers residing on the area were interviewed as to the number, size, and location of quail coveys. These counts were checked, sometimes only in part, by field counts with and without the aid of a bird dog. Utilization of tracking snows during the spring census was helpful in obtaining a count over an extensive area in a relatively short period of time.

The close cooperation that has prevailed between the farmers and research biologists has helped materially in obtaining these counts. Resident investigators have worked on the various aspects of quail ecology and management during the interim (Green and Beed, 1936; Moorman, 1942; Sanders, 1943; and Mangold, 1950).

POPULATION FLUCTUATIONS

During the 13-year period of observation, the quail population dropped to a spring population of 90 birds in 1937 and reached a fall peak of 2,974 birds in 1943 (Table 1). From 1937 through 1943 a rise in the quail population was observed and measured. Unfortunately, research during the major decline (1944 through 1948) was curtailed.

TABLE 1

BOB-WHITE QUAIL POPULATIONS ON THE 7,713-ACRE DECATUR COUNTY QUAIL RESEARCH AREA

	Spring		Fall	
Year	Numbers	Rate of Winter Mortality (Per Cent)	Numbers	Rate of Summer Increase (Per Cent)
1935	......	......	508	......
1936	228	55.7	736	222.9
1937	90	87.8	501	456.5
1938	471	6.0*	1,334	183.2
1939	1,254	6.0*	2,316	84.5
1940	389	83.2	1,549	298.2
1941	673	56.2	1,690	148.9
1942	780	53.8	2,462	215.5
1943	1,136	53.8	2,974	161.8
1944	1,102	62.9	2,500	126.9
1949	250	......	493	97.2
1950	331	32.9	527	59.2
1951	420	20.3	......	......

* Estimated loss.

Once again the birds are on a population upswing, but, to date, have failed to gain any of the 1937–39 momentum.

In discussing the rise and fall of annual populations, one needs to consider the two critical seasons for quail, summer and winter. An examination of spring and summer weather records does not reveal any relationships with the fluctuations in rates of annual increase. During the summer of 1936 the area witnessed a severe drought and grasshopper infestation. Sanders (1943) states, "No green foliage of any kind was in the field of harvested small grains, pastures or meadows. All small growth that was not seared by the hot, dry winds had been eaten by the ravenous grasshoppers. In many cases it was necessary for the farmers to feed their livestock just as they do in midwinter." Nevertheless, in spite of the most severe observed drought, quail increased 222.9 per cent by the fall of 1936. The severe winter of 1936–37, coupled with a shortage of natural food, reduced the population to 90 birds. In 1937, the vegetation was in direct contrast to 1936. All agricultural crops were above average in yield, and there was an abundance of native wild foods. Bob-whites increased by fall to 501 birds, a 456.5 per cent increase. The summer of 1938 compared favorably to 1937, but production dropped to 183.2 per cent. By 1939, following three summers of good production, the bob-white population went from 90 to 2,316 birds — an excellent example of the ability of the bob-white to recover from winter losses.

Following the severe winter of 1939–40, with losses estimated at 83.2 per cent, the rate of summer increase reached its second highest observed rate, 298.2 per cent. During the early 1940's, the population of bob-white quail appeared to level off. In 1944, indications of a decrease in production were noted. Hendrickson (1944), on examining the age composition of 914 bob-whites by analysis of the primary coverts from 14 counties in Iowa, found 721 represented birds of the year (juveniles) and 193 were birds more than a year old (adults). The ratio of juveniles to adult birds, thus, was 3.7 to 1.0 or 78.8 per cent of the sample were birds of the year. This was indicative of a low rate of production (Bennitt, 1951). On the Decatur area, a sample of 29 birds from 12 coveys revealed a ratio of 1.9 young to 1.0 adult birds. Although the sample was small, the wings were taken from a relatively large number of coveys. This was in contrast to the data from 1948, when a sample of 2,327 wings from 31 counties in Iowa were examined. A total of 2,030 (87 per cent) were from birds of the year and 297 (13 per cent) were from adult bob-whites, a ratio of 6.83 juveniles to 1.0 adult birds. Mangold (1950) examined 141 wings collected on and in the vicinity of the area during the 1949 season and found a ratio of 9.1 juveniles to 1.0 adult birds. The 1949 and 1950 data indicated a relatively high rate of production, but this was not reflected in the percentage rate of summer increase, 97 per cent for 1949 and 59.2 per cent for 1950 (Table 1). A high ratio of juvenile to adult birds in years of a low rate of summer increase could result from a high rate of mortality among adult birds.

from a late summer dispersal of adults off the area, or from an inadequate sample.

Statistical analysis of the relationship between spring and fall bob-white population (Fig. 1) revealed a highly significant correlation ($r = 0.92$, .01 level $= 0.76$). That is, fall populations were dependent to a large extent on the spring populations. Errington's data (1945) for a fifteen-year period on the Prairie du Sac area in Wisconsin, also,

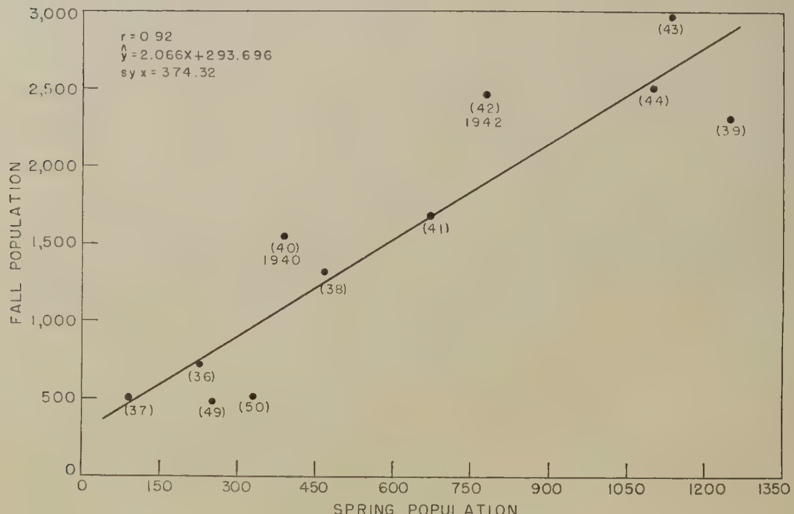

FIG. 1.—Relationship of spring and fall bob-white populations, 7713-acre Decatur County Area, Iowa.

indicated a definite relationship between spring and fall populations. In Virginia (Mosby, 1950), data collected for a five-year period did not show that the size of the fall population was dependent on the number of quail present during the preceding spring. This regional difference may be clarified with more data on spring-fall relationships.

Although the data depicts an inverse ratio in rates of summer gain (Fig. 2), this relationship is not statistically significant ($r = -0.469$, .05 level $= 0.576$). The 1949 and 1950 seasons were the primary reasons why the relationship was not more evident. No explanation can be made for the relatively poor rates of summer production in those years. Errington's data for Wisconsin (1945) revealed a strong inverse relationship of rate of summer production and spring population, except the year 1936. Perhaps the Decatur County data in 1949 and 1950 were also exceptions to this biological concept. On the other hand, there is the possibility that unmeasured changes in the vegetation may have altered the rate of summer production. Further population data may refute or substantiate this latter hypothesis.

Fall and winter losses have varied from an observed 20.3 to 87.8 per cent. Inasmuch as these losses included the hunting season, an investigation was made of hunting harvest in the fall of 1949 (Mangold, 1950). The resident investigator selected a 4,739-acre tract of the area for intensive study from October 1, 1949, to March 15, 1950. Of the 24 farmers who resided on this section, only one posted his 240-acre farm with "no hunting" signs. During the open season, November 1 to December 15, 1949, the biologist endeavored to contact all hunters. Thirteen hunt-

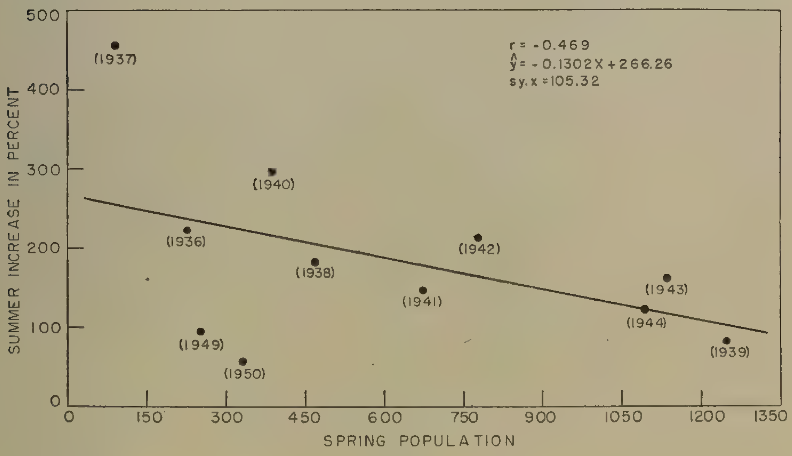

FIG. 2.—Relationship of spring bob-white populations and per cent rate of summer increase; 7713-acre Decatur County Area, Iowa.

ing parties, consisting of 34 hunters, were located during the season. This group harvested only 14 of the 305 bob-whites known to be on the area in October 31, 1949. Further, the 14 birds, 4.5 per cent of the fall population, were from only three of the 21 coveys on the area. Likewise, Errington and Hammerstrom (1934) found that hunting pressure in Iowa was not a controlling factor in fall bob-white populations on experimentally shot and unshot areas in 1933. Certainly, the evidence does not indicate that hunting pressure is a critical factor in the fall and winter losses of bob-whites on the Decatur area.

The total number of days from November through March that the snow depth was a trace or more revealed a significant statistical correlation (Fig. 3) with fall and winter losses ($r = 0.72$, .05 level $= 0.632$). Also, a significant but not as high a correlation was found between the total number of days that the snow depth was 1.0 inches or greater and fall and winter losses ($r = 0.649$, .05 level $= .0632$). The influence of snow coverage of 1.0 inches or more on bob-white population was important in Virginia (Mosby, 1950).

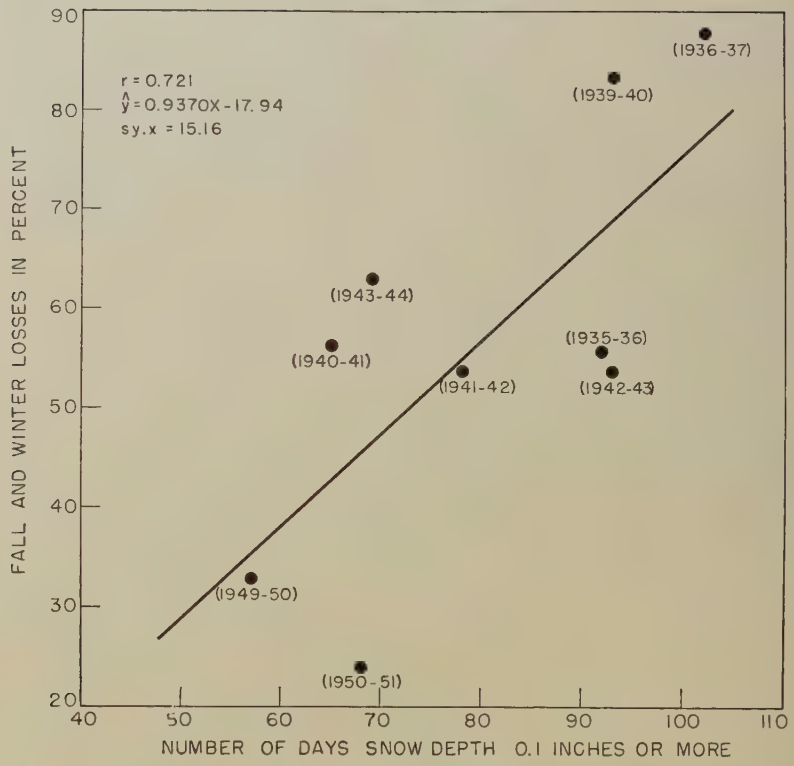

Fig. 3.—Percentage of fall and winter bob-white losses and the total number of days that the snow depth exceeded a trace or more, November through March, 7713-acre Decatur County Area, Iowa.

SUMMARY

1. Bob-white population fluctuation data are presented for the 7713-acre Decatur County Research Area from 1935–44 and 1949–51.

2. A significant statistical correlation exists between spring and fall populations ($r = 0.92$, .01 level $= 0.76$).

3. Per cent rate of summer production has varied from 59.2 to 465.5. per cent.

4. The per cent rate of summer gain depicts an inverse ratio with spring populations, but the correlation is not statistically significant. The rates of production in 1949 and 1950 were below anticipated figures.

5. Observed fall and winter losses of bob-whites has varied from 20.3 to 87.8 per cent.

6. Hunting losses were not found to be an important limiting factor in fall and winter losses.

7. The total number of days in which the snow depth exceeded a trace or more was correlated with fall and winter losses ($r = 0.721$, .05 level $= 0.632$).

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AGE AND GROWTH OF THE BLACK AND WHITE CRAPPIES, *POMOXIS NIGRO-MACULATUS* (LeSUEUR) AND *P. ANNULARIS* RAFINESQUE, IN CLEAR LAKE, IOWA [1]

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INTRODUCTION

The Iowa Cooperative Fisheries Research Unit has been carrying on annual studies of Clear Lake in Cerro Gordo County, Iowa, to determine what factors affect the abundance and growth of the various species of fish and to learn how sport fishing can be maintained and improved in this and similar lakes. The present report is concerned with the black and the white crappies. Neither species has been particularly abundant in recent years, but they contribute to many angler's catches and now that year-round fishing for these species is permitted, the crappies may provide a major part of the Clear Lake fishing in the spring. The black crappie is by far the more abundant of the two in the lake. The 1941, 1942, and 1943 specimens were collected by Dr. Reeve M. Baily and Harry M. Harrison, Jr. The 1947 specimens were collected by James Sieh, the 1948 specimens by Robert E. Cleary, and the 1949 specimens by John Parsons. The 1950 specimens were collected by Thomas S. English and the writer. Gear used in the investigation included experimental gillnets, small seines, large seines, and hook and line.

Scale envelopes were the basic recording medium. Scales were placed inside the envelopes, and lengths, weight, sex, maturity, and remarks concerning the internal organs were written on the outside in prescribed blanks. Several scales were removed from the left side of the fish, at a point just caudad of the tip of the pectoral fin as it was extended caudally and dorsally to the lateral line. Standard, fork, and total lengths were measured to the nearest millimeter. Weight was

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determined by the use of a spring platform scale with a 500 gram capacity. In those cases where investigators had recorded the measurements in inches and the weights in ounces, the data were converted to the metric system for analysis.

Standard length, measured in a straight line from the tip of the snout to the base of the hypural plate, was used in all growth calculations. In addition, total length, measured from the tip of the snout to the end of the caudal fin with the two lobes compressed, and fork length, measured from the tip of the snout to the center of the fork of the caudal fin, were recorded. Conversion factors were computed by dividing the sums of the total lengths and the fork lengths by the sum of the standard lengths, and by dividing the sum of the total lengths by the sum of the fork lengths. These factors were first computed for separate size groups of 20 mm. range (standard length), but since no definite trend was observed, they are given for the entire group as a unit.

Black Crappie

Fork length = 1.221 standard lengths
Total length = 1.284 standard lengths
Total length = 1.060 fork lengths

White Crappie

Fork length = 1.222 standard lengths
Total length = 1.284 standard lengths
Total length = 1.053 fork lengths

The total length-standard length factor for the black crappie is based on 233 fish; the fork length factors are based on 205 fish. All calculations for the white crappie are based on 44 fish.

The scales were prepared and mounted according to the method described by Lewis and Carlander (10). If any slime or dirt was adhering to the scales, they were soaked in water and then rubbed between the fingers. The cleaned scales were mounted between two microscope slides, the ends of which were secured with adhesive tape. A microprojector similar to that described by Van Oosten, Deason, and Jobes (13) was used to examine the scales at a magnification of 42 diameters. Those scales which proved difficult to read because of their lack of transparency were put to soak in distilled water and then read wet. All measurements for the determination of the body-scale relationship were made with dry scales, however. It was apparent that soaking the scales in water changed their diameters.

The annuli of the Clear Lake crappies are in most cases easily recognizable and the fact that these annuli are truly year-marks is supported by the following facts:

1. An analysis of the year-class data given in Table 1 shows that those fish which were identified by their annuli as belonging to the 1948 year-class were not abundant in any year's collection. This follow-

TABLE 1

Numbers of Black Crappie of the Various Year-Classes Taken in Clear Lake, Iowa, 1947–1950

Year Class	Year of Capture 1947	1948	1949	1950
1941	1	....	....	....
1942	1	....	....	....
1943	2	....	....	....
1944	4	....	1	....
1945	8	....	8	1
1946	6	4	42	2
1947	43	22	59	7
1948	....	....	7	4
1949	....	....	66	37
1950	....	....	....	102

through of a scarce year-class through three years of life lends support to the assumption that the annulus is truly a year-mark.

2. An analysis of the growth increment from the time of formation of the last annulus to the time of capture (Tables 2 and 3) shows a consistent increase in the increment through the spring, summer, and early autumn. The results of this analysis conform to the theory that the annulus is formed in the spring when the season's growth begins. The figures for the black crappie indicate that a majority (7 out of 9) of the fish taken in the first two weeks in June had not formed the annulus as yet. Possibly 3 of the 49 taken in the last two weeks in June had not yet formed the annulus.

3. There is a correlation between the age of a fish and its size. Tables 5 and 10 show that, although there is considerable variation in the size of fish of the same age group, the general trend is one which shows an increase in size along with an increase in the number of annuli.

TABLE 2

Growth Increment Since Last Annulus of Clear Lake Black Crappie, by Age Classes and Time of Capture, 1941–1950

Date of Capture	Age I No.	Age I Mean Increment (Mm.)	Age II No.	Age II Mean Increment (Mm.)	Age III No.	Age III Mean Increment (Mm.)
June 1–15	0	....	7	36	2	38
June 16–30	2	30	22	31	19	16
July 1–15	18	44	12	36	7	19
July 16–31	28	46	13	40	8	23
Aug. 1–15	14	56	12	48	10	25
Aug. 16–31	6	68	5	54	9	26
Sept. 23–24	4	63	1	22	1	29
Oct. 13	0	....	0	....	4	38

TABLE 3

Growth Increment Since Last Annulus of Clear Lake White Crappie of Age-Class I, by Time of Capture, 1941–1950

Date of Capture	Number	Mean Increment
		(Mm.)
June 17–22	2	46
July 6–14	3	65
July 16–28	21	70
Aug. 1–11	7	79
Aug. 17–29	3	93

Black Crappie

To determine the average body-scale relationship the 299 black crappie from Clear Lake were placed into 20 mm. groups and the mean standard length was plotted against the mean anterior scale radius (x42), and a line was fitted to the data by the method of least squares. A straight line with an intercept of 8.785 mm. and a slope of 0.957 best fitted the scatter diagram. On the basis of this evidence, growth was calculated on a straight line basis using the approximate value of *a*, or 9 mm. as a base rather than zero (5). The deviations from the straight line suggest a sigmoid curve but the straight line is believed to give as accurate a fit as is justified by the data (Table 4).

TABLE 4

Body-Scale Relationship of Black Crappie From Clear Lake, Iowa

Number of Fish	Mean Scale Radius (x42)	Mean Standard Length	Calculated Length*
	(Mm.)	(Mm.)	
7	67	73	73
35	77	89	82
29	97	106	102
41	131	129	134
45	156	150	158
47	176	172	177
10	205	201	205
13	239	249	238

* Calculated length = 8.8 mm. plus 0.957 times the scale radius.

Since there was virtually no difference between the growth rates of the fish collected in the different years, the data were combined (Table 5). The average annual increments show that the fish added more length in their second year than in their first; the tendency in succeeding years is one of gradual decrease in the increment. A possible explanation for this greater growth in the second year can be obtained from an examination of the time of hatching. Eddy and Surber (6) give the spawning time for the black crappie in Minnesota as May

and June, and occasionally in July. Table 6 shows that no investigator found young crappie in Clear Lake before the first of July, which would indicate that they seldom spawn in that lake earlier than June. It seems reasonable to conclude from this that the average black crappie does not have a complete year in his first season, and thus would not be expected to grow as much as in the second. The gradual nature of

TABLE 5

AVERAGE CALCULATED LENGTHS OF BLACK CRAPPIE IN EACH AGE GROUP COLLECTED AT CLEAR LAKE, IOWA, 1941–1950

Age Class	Number Examined	Standard Length in Mm. at Each Annulus							Standard Length at Capture		Number	Mean Weight, Grams
		1	2	3	4	5	6	7	Mean	Range		
0	340	.....	.....	.....	.....	.....	.....	.....	30	9–66	.....	.....
I	72	45	.....	.....	.....	.....	.....	.....	95	64–145	63	30
II	72	46	103	.....	.....	.....	.....	.....	140	103–183	60	92
III	60	46	103	144	.....	.....	.....	.....	167	128–246	53	149
IV	12	51	101	139	166	.....	.....	.....	187	142–231	9	223
V	7	46	91	142	183	212	.....	.....	234	177–259	5	348
VI	5	45	78	136	181	206	231	.....	251	246–256	1	312
VII	1	36	70	128	155	190	226	235	248	.....	.....	.....

Grand Averages From Above Table (229 fish)

Standard length	46	101	142	173	208	230	235
Average annual increment	46	55	43	35	28	27	9
Corresponding total length in inches	2.3	5.1	7.2	8.7	10.5	11.6	11.9
Average weight in grams*	3	33	92	166	288	391	415
Weight increment*	3	30	61	81	101	122	45
Average weight in ounces*	0.1	1.2	3.2	5.9	10.1	13.8	14.6

* Computed by length-weight formula presented in later discussion.

the decrease in the average annual increment through later years of life is quite typical of the growth of fishes.

The growth histories of some of the individual fish present an interesting picture of individual variation. The fish which was the longest of the entire group at the end of the first year of life was a two-year-old, and was longer than average at the end of the second year. The fish which was the longest at the end of the second year of life was a three-

year-old, and had grown fast through all its three years, being longer at the end of its third year than the average crappie was at the end of the fourth. The fish which was longest at the end of its third year had quite a different history, however; it was smaller than ave age at the end of the first year, a little larger than average at the er d of the second year, and, at the end of the third year it was as long a the average

TABLE 6
GROWTH OF BLACK CRAPPIE YOUNG-OF-THE-YEAR FROM CLEAR LAKE, IOWA, 1943–1950

Date of Capture	Number of Fish	Standard Length in Mm. at Capture	
		Mean	Range
1943.(1)			
July 10	15	22.8	18–26
July 21	40	28.2	23–33
Aug. 6	27	39.1	34–51
Oct. 29	47	53.0	44–66
1947.(2)			
July 13	18	18.7	...
July 18	3	26.5	...
July 26	8	27.3	...
Aug. 1, 2	4	28.0	...
Aug. 5	6	35.8	...
Aug. 9	4	37.4	...
1949.(4)			
July 2–16	25	28.6	21–31
Aug. 2–16	15	45.4	41–54
Aug. 17–Sept. 1	26	49.1	44–54
1950			
July 18	5	14.0	9–19
July 25	29	12.4	9–19
July 28	7	15.7	9–25
uly 31	28	15.5	9–19
Aug. 2	24	12.7	9–19
Aug. 8	2	17.7	16–19
Aug. 13–15	5	20.2	16–21
Aug. 24	2	19.9	16–21
1950 (Ventura Marsh)			
July 28	18	35.4	22–47
Aug. 1–2	39	45.6	36–51
Aug. 15	58	48.2	36–55
Sept. 24	17	60.5	51–70

crappie at the end of the fifth year. Of the three which showed the greatest length by the end of the fourth year, two were considerably larger than average through their first three years also, but e third was below the average in every one of the first three years. ne last mentioned fish was a six-year-old, and, although it continued to be longer than average, it gained less than the average annual increment in succeeding years.

A comparison of the lengths of the young-of-the-year fish through the growing seasons of 1943, 1947, 1949, and 1950 (Table 6) shows that the young were growing quite similarly in the first three years, but the 1950 young were very retarded. The lengths when first captured in early July indicate that the 1950 hatch was probably later than that of former years. The data in Table 6 also suggest that the spawning may have been sporadic.

The growth of the young-of-the-year black crappies collected from the Ventura Marsh gives a clue as to a possible explanation of the slow growth of the 1950 young-of-the-year in the lake. The Ventura Marsh is situated at the extreme west end of Clear Lake, and was cut off from the lake in the summer of 1950 by a gate and a rough fish trap. The marsh is composed primarily of very shallow water, and its maximum depth is about 8 feet, whereas the lake has considerable quantities of deeper water, with a maximum depth of about 21 feet. The water in the marsh warms up earlier in the summer than does that of the lake. It is difficult to set any positive time of spawning from the data from Ventura Marsh, but it is apparent that the crappies were hatched earlier than those in Clear Lake. A comparison of the sizes of the young from the two bodies of water indicates that they grew faster in the marsh as well as hatched earlier. With this information, an explanation of the relatively slow growth of the 1950 year-class in Clear Lake can be postulated. The summer of 1950 was unusually cold and windy, so it can safely be concluded that the overall water temperature was much lower than it was at similar times in former years. The mean temperature in May was 2.5°F. below normal, in June 1.3° below normal, in July 5.5° below normal, and in August 4.7° below normal (U.S.D.A. Climatological Data). This caused the adult crappies to spawn later and the young to grow more slowly. In contrast in 1949 when the young crappies grew very rapidly, the May temperature was 3.0° above normal, in June 3.0° above, in July 2.3° above, and in August 1.6° above normal.

Carlander (3) has summarized growth data for black crappies from various parts of the country, and the majority of these show faster growth than the Clear Lake black crappie. The averages for Minnesota, Indiana, Ohio and Iowa are relatively close to those for Clear Lake. There appears to be a much greater difference in the growth of crappies in the South, where they grow both faster and larger than they do farther north. There is some suggestion, however, that they live longer in the North.

The only available data on growth of black crappies in Iowa is contained in a study of two artificial lakes in southern Iowa (9). The black crappies from both East Lake and Red Haw Lake grow larger in a shorter time than do those of Clear Lake; however, a comparison of the average annual increments shows that the growth tends to drop off more abruptly in both Red Haw Lake and East Lake than it does in Clear Lake.

The available data on 43 black crappies indicates that the majority are ready to spawn in their third year. Of the immature females in the sample of Clear Lake black crappies, the largest was 5.6 inches in total length and was in its second year; the largest of the immature males was 9.0 inches and was in its fourth year. The latter may have been mature earlier, but the gonads were not developed at the time of capture, August 17, 1950. Of the mature fish, the smallest female was 5.35 inches and in its second year, and the smallest male was 7.4 inches and in its third year. These are, of course, the extremes and not the averages. Perhaps a word of explanation regarding the smallest mature female is in order: she was captured in late August, and had eggs forming in the ovaries. She probably had not spawned in the spring of her second year, but would have been ready to spawn in the spring of her third year.

It has been shown (7) that the length-weight relationship of various fish may in general be expressed by the following equation: $W = CL^n$; where W is the weight, L is the length, and C and n are constants. For the sake of computation of these constants, the standard lengths and weights of the Clear Lake black crappies were converted to logarithms and a straight line fitted to the data by the least squares method. This length-weight relationship was computed separately for each year's collection and for the sexes, when such data were available. An analysis of covariance was computed to determine if the various regression coefficients, or b values, were significantly different from each other (Table 7). The F value of 1.050 with degrees of freedom 4 and 157 shows that differences in those regression coefficients to be not significant

TABLE 7

Analysis of Covariance for the Length-Weight Relationship of Clear Lake Black Crappie, 1947, 1949, 1950

Lot	D.F.	Sums of Squares and Cross-Products			b	Errors of Estimate		
		Sx^2	Sxy	Sy^2		Sum of Squares	d.f.	Mean Square
1950 males	13	0.243	0.734	2.253	3.021	0.036	12	....
1950 females	16	0.162	0.488	1.491	3.017	0.021	15	....
1950 sex unknown	15	0.238	0.726	2.238	3.058	0.023	14	....
1949 combined	106	0.576	1.680	5.063	2.916	0.163	105	....
1947 combined	12	0.238	0.740	2.357	3.114	0.056	11	....
						0.299	157	0.001904
Sums	162	1.457	4.368	13.402	....	0.307	161	....
Difference	....	....	....	....	....	0.008	4	0.0020000

F = 0.0020000/0.001904 = 1.050, not significant.

at the 5 per cent level (12). On the basis of this analysis, the length-weight relationship is presented for the entire collection of 169 fish (Table 8). Two fish could not be included in the analysis of covariance because they were the single representatives of the 1942 and 1943 collection; but since they did not appear to vary greatly from the average, they are included in the computation of the length-weight relationship of the entire group.

The straight line which best fitted the scatter diagram of the logarithms of the lengths and weights of the Clear Lake black crappie had

TABLE 8

THE LENGTH-WEIGHT RELATIONSHIP OF CLEAR LAKE BLACK CRAPPIE, 1942–1950

Average Standard Length in Millimeters	Number of Fish	Average Weight in Grams	
		Observed	Computed*
77	5	14	15
86	11	20	21
94	12	28	27
104	9	36	36
114	5	48	48
125	25	64	63
135	11	80	79
144	20	100	96
155	20	123	120
164	14	146	142
173	15	167	166
184	7	203	200
191	4	222	225
203	4	280	269
214	2	251	313
231	1	345	396
246	3	440	476
252	1	524	510

* $\text{Log } W = -4.459 + 2.985 \text{ Log } L$.

an intercept of —4.459 and a slope of 2.985. Thus the formula $\text{Log } W = -4.459 + 2.985 \text{ Log } L$, can be used to estimate unknown weights of black crappies from Clear Lake.

The value of b, 2.985, shows that the length-weight relationship approaches that in which the weight increases as the cube of the length; which is to be expected if the fish retains the same body shape throughout life. To substantiate this assumption of cubic relationship, the standard deviation of the b value, and the 95 per cent confidence interval estimate were computed. The standard deviation of the b value, is 0.0358. The 95 per cent confidence limits are 3.056 and 2.914 which indicate that the weight increase does not differ significantly from the cubic law.

The coefficient of condition, or K factor, is a numerical representation of the relation of a fish's weight to its length; a thin fish will have

a lower K value than a plump one. The coefficient of condition is computed by the formula

$$K = \frac{W\,10^5}{L^3}$$

where W is the weight in grams and L is the standard length in millimeters.

The average K of the Clear Lake black crappie taken in 1942 (1 fish) was 3.44; in 1943 (1 fish), 3.32; in 1947 (13 fish), 3.28 in 1949 (107 fish), 3.22; in 1950 (47 fish), 3.31; giving a grand average for 169 fish of 3.25. Since this value is higher than that reported for Minnesota (3) and for southern Iowa (9), we could presume that, although the Clear Lake black crappies grew slower in length than did those from some other comparable areas, they maintained a better than average relative weight.

To determine if the fish collected in various years differed significantly as to plumpness, another analysis of covariance was computed (11). This analysis is presented in Table 9. The F value of 0.665 with degrees of freedom 4 and 161 shows that the differences in weight in the various lots, adjusted to a constant length, are not significant at the 5 per cent level.

The computed length-weight relationship

$$\text{Log } W = -4.459 + 2.985 \text{ Log } L$$

was used to estimate the weights of the crappies at various ages (Table 5). Although the length growth increment per year decreases after the second year, the weight increment continues to increase at least through the sixth year.

In the summer of 1950, 57 stomachs of black crappie were examined. Records were kept of the types of food found, the size of the specimen,

TABLE 9

Analysis of Covariance for Test of Significance of Differences Among Adjusted Group Means of Clear Lake Black Crappie, 1947, 1949, 1950

Source of Variation	d.f.	Sums of Squares and Cross-Products			Errors of Estimate		
		Sx^2	Sxy	Sy^2	Sum of Squares	d.f.	Mean Square
Total	166	1.457	4.368	13.402	0.307	165	....
Lots	4	0.735	2.164	6.372	....	....	....
Within Lots	162	0.722	2.204	7.030	0.302	161	00188
Difference	....	....	....	....	0.005	4	.00125

F = 0.00125/0.00188 = 0.665, not significant.

and the date of capture. No attempt was made to determine the volume of the food or the percentage of various organisms in the stomach, as the food was found in various stages of digestion. Of the 57 stomachs, 26 contained entomostraca, 17 were empty, 4 contained insects, 3 contained vegetation, 3 contained *Hyalella* sp., 3 contained fish, and 1 contained only unidentifiable debris.

A study of the total lengths of the fish which had eaten the various organisms shows that entomostraca were eaten by fish ranging from 3.7 inches to 8.6 inches; insects were eaten by fish from 4.8 inches to 5.6 inches; vegetation appeared in stomachs of fish from 4.8 to 8.0 inches long; *Hyalella* sp. in fish from 5.4 to 5.8 inches long; fish remains were found in black crappies from 5.3 to 7.4 inches long.

The dates when the various foods were found point further to the importance of entomostraca in the diet of the black crappie; those organisms were found in stomachs throughout the entire summer and into September. Vegetation appeared in the diet only between July 18 and July 28. Insects, as noted above, were not common in the diet, but they were found from July 28 until September 24. Fish were found in the diet only during one week in mid-August. The *Hyalella* sp. were found only on September 24.

The same 57 black crappies which were examined for food were examined also for parasites. The heart, liver, and kidneys were inspected in each of them. Of these 57, four were found to have white grubs, probably *Posthodiplostomum minimum*, in the liver.

White Crappie

The 44 white crappies from Clear Lake were placed into 40 mm. groups, the mean standard length was plotted against the mean anterior scale radius (x42), and a line was fitted to the data by the least squares method. A straight line with an intercept at a standard dength of 30.048 mm. and a slope of 0.960 gave the best fit to the scatter diagram; but, since such a line would obviously give too large an increment for the first year and since the number of specimens was not adequate for a better description of the relationship, the growth rates were determined on the basis of a direct proportion, as with the Dahl-Lea formula (8).

Only 8 of the white crappies were past their second winter (Table 10). The 1948 collection of white crappies consisted of 3 fish. One of these was a three-year-old and the other two were two-year-olds. The 1949 collection consisted of 18 fish, 14 of which were one-year-olds. The 1950 collection consisted of 23 fish, 22 of which were one-year-olds. The twenty-third fish in the 1950 collection was a three-year-old; not one fish of the 1948 year-class, which was so predominant in the 1949 collection, showed up in the 1950 collection.

The length-weight relationship of the white crappie was calculated in the same manner as that described previously for the black crappie: the lengths and weights were converted to logarithms and a straight

line fitted to the data by the least squares method. Since the sample was so small, no attempt was made to keep the sexes or the time of collection separate in the computations.

The straight line which best fitted the scatter diagram of the logarithms of the lengths and weights of the Clear Lake white crappies had an intercept of −5.308 and a slope of 3.376. These values can be sub-

TABLE 10
AVERAGE CALCULATED LENGTHS OF WHITE CRAPPIE IN EACH AGE GROUP COLLECTED AT CLEAR LAKE, IOWA, 1948–1950

Age Class	Number Examined	Standard Length in Mm. at Each Annulus			Standard Length at Capture		Number	Mean Weight, Grams
		1	2	3	Mean	Range		
I	36	38	....	....	110	82–157	36	40
II	4	41	113	....	153	140–183	3	110
III	4	45	86	146	176	165–186	3	171
		Grand Averages (44 fish)						
Standard Length		39	100	146				
Average annual increment		39	57	60				
Corresponding total length in inches		2.0	5.1	7.4				
Average weight in grams		1	28	100				
Weight increment		1	26	83				
Average weight in ounces		.04	1.0	3.5				

stituted into the formula $\text{Log } W = -5.308 + 3.376 \text{ Log } L$, which may be used to estimate unknown weights of fish from the same population (Table 11).

To determine if the length-weight relationship approached the cubic relationship which characterized the black crappie, the standard deviation of the b value, the 95 per cent confidence interval estimate, and a t-test were computed. The standard deviation of the b value, s_b, is 0.0722. The 95 per cent confidence limits are 3.521 and 3.231. The t-test gave a value of $t = 5.21$, which is significant at the 1 per cent level. We can conclude with reasonable safety that the length-weight relationship of this sample of white crappies is not one in which the weight increases as the cube of the length. The larger fish are heavier for their length than the smaller ones.

The average K value for the 42 white crappies was 2.95. This, like the comparable value for the black crappies, is higher than that reported

TABLE 11

The Length-Weight Relationship of Clear Lake White Crappie, 1948–1950

Average Standard Length in Millimeters	Number of Fish	Average Weights in Grams	
		Observed	Calculated*
86	3	20	17
98	6	26	26
107	14	36	35
116	7	47	46
127	3	49	62
134	2	71	75
144	3	111	95
157	1	107	128
165	1	168	150
184	2	172	218

* $\text{Log } W = -5.308 + 3.376 \text{ Log } L$.

for southern Iowa (9) and for Minnesota (3). Although they are not as plump or as long-lived as the black crappie, it appears that the Clear Lake white crappie compare quite favorably to fish of the same species from other lakes in nearby areas.

Twenty-three stomachs of white crappies were examined in the summer of 1950. Ten stomachs were empty, 8 contained entomostraca, 4 contained insects, and 2 contained vegetation.

SUMMARY

Black Crappie

1. The study of Clear Lake black crappie was based on 237 adult fish and 340 young-of-the-year fish collected in 1941, 1942, 1943, 1947, 1948, 1949, and 1950.
2. The 1948 year-class was found to be consistently scarce through three years of collection.
3. The majority of the crappies had apparently not formed the annulus by the middle of June, but all had formed it by the first of July.
4. The body-scale relationship can best be described by a straight line having an intercept of 8.785 mm. and a slope of 0.957.
5. The greatest growth in length was in the second year. The increment decreased gradually each year thereafter.
6. The 1950 young-of-the-year were noticeably retarded in growth, probably because of the unusually late spring and cool summer.
7. Maturity is usually reached by the third spring when the fish just becomes a member of age-group II.
8. The relationship between standard length (L) and weight (W) can best be described by the formula: $\text{Log } W = -4.459 + 2.985 \text{ Log } L$.
9. An analysis of covariance failed to show significant differences between the regression coefficients of the length-weight relationships for the fish captured in different years.

10. The average coefficient of condition, K, for 169 fish was 3.25, which is higher than that reported for black crappie in nearby waters.

11. Fifty-seven stomachs were examined for food. Entomostraca appeared to be a basic part of the diet at all times and for all sizes of black crappie.

12. Four of the 57 black crappies were found to have white grubs, probably *Posthodiplostomum minimum,* in the liver.

White Crappie

1. The study of Clear Lake white crappie was based on 44 adult fish collected in 1948, 1949, and 1950.

2. The average increment in length increases steadily through the three years of life; but, the growth during the third year may be overestimated as the sample size is quite small.

3. The formula for the length-weight relationship describes a straight line: Log W = —5.308 + 3.376 Log L.

4. The average K for 42 white crappies was 2.95, which is higher than that reported for white crappies in nearby waters.

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